State of California
The Resources Agency
Department of Water Resources

FINAL REPORT
EVALUATION OF OROVILLE FACILITIES OPERATIONS ON WATER TEMPERATURE-RELATED EFFECTS ON PRE-SPAWNING ADULT CHINOOK SALMON AND CHARACTERIZATION OF HOLDING HABITAT
SP-F10, TASKS 1D AND 1E

Oroville Facilities Relicensing
FERC Project No. 2100

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REPORT SUMMARY

The purpose of SP-F10 Task 1E is to identify and characterize adult early up-migrant (spring-run) Chinook salmon (*Oncorhynchus tshawytscha*) holding habitat and use patterns in the lower Feather River below the Thermalito Diversion Dam. The purpose of SP-F10 Task 1D is to evaluate the effects of Oroville Facilities operations on water temperature-related effects on pre-spawning salmonid adult production. Because SP-F10 Task 1E evaluated pre-spawning adult spring-run Chinook salmon habitat focusing on water temperatures in potentially suitable holding pools, portions of SP-F10 Task 1D also were included in this report. However SP-F10 Task 1D conceptually overlaps with other study plans and information presented in the Final Reports associated with SP-F10 Task 2B and SP-F10 Task 2C also help elucidate the effects of water temperatures on pre-spawning adult salmonid production.

Ongoing operations of the Oroville Facilities affect instream flow in the lower Feather River, which, in turn, influence water temperatures in potential holding habitat for spring-run Chinook salmon. The results of this study provide information regarding potential spring-run Chinook salmon holding habitat and factors that could affect pre-spawning adult Chinook salmon production. Additionally, the results of this study could be used to evaluate future potential Resource Actions involving water temperature and flow manipulation in the lower Feather River.

To complete Tasks 1D and 1E of SP-F10, a literature review was conducted to determine the immigration and holding period for spring-run Chinook salmon in the lower Feather River, and to determine water temperatures at which potential individual physiological or population effects could occur. Two sets of thermal tolerance ranges were obtained from the literature review to which observed water temperatures were compared separately for the Interim and Final reports for SP-F10 Task 1E. The results of the literature review were provided as part of the reports associated with SP-F10 Task 1E and SP-F10 Task 1D.

Water temperature data were collected during the 2002 and 2003 spring-run Chinook salmon immigration and holding period to which reported thermal tolerance ranges could be compared. Pool profile water temperature data were collected from 16 pools during 2002 and 2003. Additionally, water temperature data generally were collected every 15 minutes from thermographs located in 24 pools during the 2003 immigration and holding period.

Upon completion of the literature review conducted for the Interim Report for SP-F10 Task 1E (Interim Report), an analysis was conducted to determine the availability of suitable habitat during the 2002 spring-run Chinook salmon immigration and holding period based on water temperatures reported to be suitable, to have potential sublethal effects on individuals, and to be the upper incipient lethal water temperature range.

Analysis conducted for the Final Report for SP-F10 Task 1E (Final Report) was similar to analysis conducted for the Interim Report. However, the subjective nature of the three categories chosen for analysis in the Interim Report and additional thermograph data justified reevaluation of the analytical procedure. For the Final Report, the percentage of time that water temperatures were above specific index water temperatures during the defined spring-run Chinook salmon immigration and holding period in 2003 at each water temperature data collection location in the Feather River were analyzed. The reported biological effects that could occur when water temperatures are at or above each index value also were presented.

Water temperature profile data were obtained from 16 pools during the 2002 spring-run Chinook salmon immigration and holding period. Water temperature profile and thermograph data were obtained from nine pools in 2003. Only water temperature profile data were obtained from seven pools, and only thermograph data were recorded at the bottom of fifteen pools.

During the 2002 sampling period, some water temperature data were lost making interpretation with respect to habitat suitability difficult. However, data collected during spring, summer, and early fall 2002 indicate that water temperatures generally are suitable for adult spring-run Chinook salmon immigration and holding from the Fish Barrier Dam to Mathews Riffle (RM 67 to RM 64), with suitability decreasing during some portions of the immigration and holding period as distance downstream from the Thermalito Diversion Dam increased. Additionally, at all sample sites, dissolved oxygen concentration was within the reported suitable range for holding adult spring-run Chinook salmon on all sample dates. Pools of reported suitable depth are available during the holding period; however, not all pools sampled were of suitable depth throughout the entire holding period.

During the 2003 sampling period, an estimated total of 66 percent of mean water temperature profile data in 15 pools in the lower Feather River exceeded the index value of 15.6°C (60°F). Forty-eight percent of mean water temperature profile data in 11 pools exceeded the index value of 17.8°C (64°F). An estimated total of nine percent of mean water temperature profile data in 10 pools exceeded the index value of 20°C (68°F).

An estimated total of 51 percent of the mean daily thermograph water temperature data in 13 pools and 61 percent of weekly mean thermograph water temperature data in 11 pools in the lower Feather River exceeded the index value of 15.6°C (60°F). Twenty-two percent of daily and weekly mean thermograph water temperature data in 10 pools exceeded the index value of 17.8°C (64°F) during the 2003 adult spring-run Chinook salmon immigration and holding period. Daily and weekly thermograph water temperature data never exceeded the index value of 20°C (68°F) during the 2003 adult spring-run Chinook salmon immigration and holding period. Therefore, continued operation of the Oroville facilities in a manner consistent with current operations would be expected to result in water temperatures conducive to adult spring-run Chinook salmon immigrating and holding in the lower Feather River.

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1.0 INTRODUCTION

1.1 BACKGROUND INFORMATION

Ongoing operation of the Oroville Facilities influences flows and water temperatures in the Feather River downstream from the Thermalito Diversion Dam. Water temperature is an important factor influencing the suitability of adult spring-run Chinook salmon immigration corridors and holding habitat. As a component of study plan (SP)-F10, *Evaluation of Project Effects on Salmonids and their Habitat in the Feather River Below the Fish Barrier Dam,* Task 1 of SP-F10 evaluates the effects of Feather River water temperatures and flow on upmigrating and holding adult Chinook salmon in the lower Feather River. Tasks 1D and 1E, herein, evaluate the effects of water temperatures on early upmigrating (spring-run) adult Chinook salmon (*Oncorhynchus tshawytscha*) production, holding habitat, and habitat use patterns in the lower Feather River.

1.1.1 Statutory/Regulatory Requirements

SP-F10 Tasks 1D and 1E evaluate effects of water temperature on adult holding spring-run Chinook salmon in the lower Feather River. Salmonids present in the lower Feather River include spring-run Chinook salmon, fall-run Chinook salmon, and steelhead (*O. mykiss*). On September 16, 1999, naturally-spawned Central Valley spring-run Chinook salmon were listed as threatened under the federal Endangered Species Act (ESA) by the Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service (NOAA Fisheries) (NOAA Fisheries 1999). The Central Valley spring-run Chinook salmon Evolutionarily Significant Unit (ESU) includes all naturally-spawned populations of spring-run Chinook salmon in the Sacramento River and its tributaries, which includes naturally-spawned spring-run Chinook salmon in the lower Feather River (NOAA Fisheries 1999).

The results and recommendations from this study fulfill, in part, statutory and regulatory requirements mandated by the ESA as it pertains to Central Valley spring-run Chinook salmon. In addition to the ESA, Section 4.51(f)(3) of 18 CFR requires reporting certain types of information in the Federal Energy Regulatory Commission (FERC) application for license of major hydropower projects, including a discussion of the fish, wildlife, and botanical resources in the vicinity of the project (FERC 2001). The discussion is required to identify the potential impacts of the project on these resources, including a description of any anticipated continuing impact for on-going and future operations. As subtasks of SP-F10, Tasks 1D and 1E fulfill a portion of the FERC application requirements by detailing the effects of water temperatures on adult spring-run Chinook salmon production, holding habitat, and habitat use patterns in the lower Feather River. In addition to fulfilling these requirements, information collected during this task may be used in developing or evaluating potential Resource Actions.

1.1.2 Study Area

The study area in which the results of Tasks 1D and 1E of SP-F10 apply is the lower Feather River from the Thermalito Diversion Dam to the confluence with the Sacramento River.

For the purposes of the analysis conducted for the Interim Report for SP-F10 Task 1E (Interim Report), which analyzed data collected during a portion of the 2002 immigration and holding period, the study area was broken down into four reaches: the Fish Barrier Dam to Mathews Riffle (RM 67 to RM 64); Mathews Riffle to the Thermalito Afterbay Outlet (RM 64 to RM 59); the Thermalito Afterbay Outlet to Honcut Creek (RM 59 to RM 44); and Honcut Creek to the confluence of the Feather River with the Sacramento River (RM 44 to RM 0). Each reach was numbered from upstream to downstream beginning with the reach from the Fish Barrier Dam to Mathews Riffle (Reach 1). Within each reach, pools were labeled numerically from upstream to downstream. For example, the most upstream pool that was sampled was designated Pool 1-1 while the most downstream pool for which data was collected was designated Pool 4-5.

Because thermographs were installed in some pools to record water temperatures every fifteen minutes during the 2003 spring-run Chinook salmon immigration and holding period, analysis of the thermograph data collected in 2003 was presented differently from the data collected during the 2002 immigration and holding period. Pools in which thermographs were installed, were not numbered and analysis of the data was presented using pool names presented in Figures 4.1-1 and 4.1-2. Analysis of pool profile data collected during the 2003 spring-run Chinook salmon immigration and holding period was presented using the same pool nomenclature as the analysis presented for pool profile data collected during the 2002 spring-run Chinook salmon immigration and holding period.

1.1.2.1 Description

Water temperature plays an important role in the timing of upstream migration of adult salmonids. Adult salmonids are transiently exposed to the warm water temperatures of the Delta and lower reaches of the Sacramento River before entering and ascending to cooler reaches of the Feather River. Under current conditions, exposure to cooler water in the lower Feather River is dependent largely on the operations of the Oroville-Thermalito complex. If water temperatures encountered by upmigrating salmonids in the Feather River were cooler than those in the upper Sacramento River, the Feather River salmonids may be encouraged to continue their migration to their natal spawning grounds in the Feather River, thus decreasing the likelihood of straying into the upper Sacramento River.

1.2 DESCRIPTION OF FACILITIES

The Oroville Facilities were developed as part of the State Water Project (SWP), a water storage and delivery system of reservoirs, aqueducts, power plants, and pumping plants. The main purpose of the SWP is to store and distribute water to supplement the needs of urban and agricultural water users in northern California, the San Francisco Bay area, the San Joaquin Valley, and southern California. The Oroville Facilities are also operated for flood management, power generation, to improve water quality in the Delta, provide recreation, and enhance fish and wildlife.

FERC Project No. 2100 encompasses 41,100 acres and includes Oroville Dam and Reservoir, three power plants (Hyatt Pumping-Generating Plant, Thermalito Diversion Dam Power Plant, and Thermalito Pumping-Generating Plant), Thermalito Diversion Dam, the Feather River Fish Hatchery and Fish Barrier Dam, Thermalito Power Canal, Oroville Wildlife Area (OWA), Thermalito Forebay and Forebay Dam, Thermalito Afterbay and Afterbay Dam, and transmission lines, as well as a number of recreational facilities. An overview of these facilities is provided on Figure 1.2-1. The Oroville Dam, along with two small saddle dams, impounds Lake Oroville, a 3.5-million-acre-feet (maf) capacity storage reservoir with a surface area of 15,810 acres at its normal maximum operating level.

The hydroelectric facilities have a combined licensed generating capacity of approximately 762 megawatts (MW). The Hyatt Pumping-Generating Plant is the largest of the three power plants with a capacity of 645 MW. Water from the six-unit underground power plant (three conventional generating and three pumping-generating units) is discharged through two tunnels into the Feather River just downstream of Oroville Dam. The plant has a generating and pumping flow capacity of 16,950 cfs and 5,610 cfs, respectively. Other generation facilities include the 3-MW Thermalito Diversion Dam Power Plant and the 114-MW Thermalito Pumping-Generating Plant.

Thermalito Diversion Dam, four miles downstream of the Oroville Dam creates a tail water pool for the Hyatt Pumping-Generating Plant and is used to divert water to the Thermalito Power Canal. The Thermalito Diversion Dam Power Plant is a 3-MW power plant located on the left abutment of the Diversion Dam. The power plant releases a maximum of 615 cubic feet per second (cfs) of water into the river.

The Power Canal is a 10,000-foot-long channel designed to convey generating flows of 16,900 cfs to the Thermalito Forebay and pump-back flows to the Hyatt Pumping-Generating Plant. The Thermalito Forebay is an off-stream regulating reservoir for the 114-MW Thermalito Pumping-Generating Plant. The Thermalito Pumping-Generating Plant is designed to operate in tandem with the Hyatt Pumping-Generating Plant and has generating and pump-back flow capacities of 17,400 cfs and 9,120 cfs, respectively. When in generating mode, the Thermalito Pumping-Generating Plant discharges into the Thermalito Afterbay, which is contained by a 42,000-foot-long earth-fill dam. The

Afterbay is used to release water into the Feather River downstream of the Oroville Facilities, helps regulate the power system, provides storage for pump-back operations, and provides recreational opportunities. Several local irrigation districts receive water from the Afterbay.

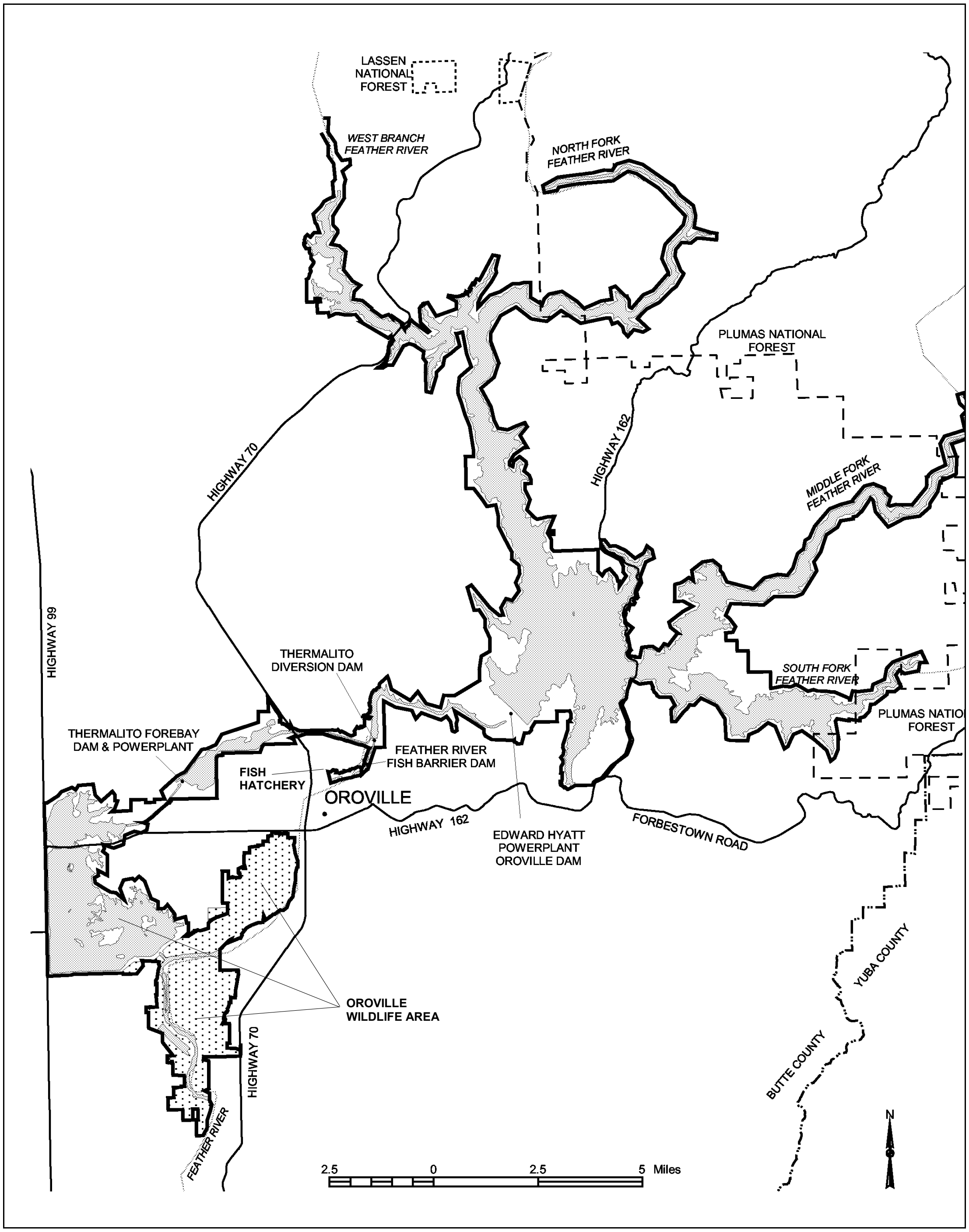

Figure 1.2-1. Oroville Facilities FERC Project Boundary.

The Feather River Fish Barrier Dam is downstream of the Thermalito Diversion Dam and immediately upstream of the Feather River Fish Hatchery. The flow over the dam maintains fish habitat in the low-flow channel of the Feather River between the dam and the Afterbay outlet, and provides attraction flow for the hatchery. The hatchery was intended to compensate for spawning grounds lost to returning salmon and steelhead trout from the construction of Oroville Dam. The hatchery can accommodate an average of 15,000 to 20,000 adult fish annually.

The Oroville Facilities support a wide variety of recreational opportunities. They include: boating (several types), fishing (several types), fully developed and primitive camping (including boat-in and floating sites), picnicking, swimming, horseback riding, hiking, off-road bicycle riding, wildlife watching, hunting, and visitor information sites with cultural and informational displays about the developed facilities and the natural environment. There are major recreation facilities at Loafer Creek, Bidwell Canyon, the Spillway, North and South Thermalito Forebay, and Lime Saddle. Lake Oroville has two full-service marinas, five car-top boat launch ramps, ten floating campsites, and seven dispersed floating toilets. There are also recreation facilities at the Visitor Center and the OWA.

The OWA comprises approximately 11,000-acres west of Oroville that is managed for wildlife habitat and recreational activities. It includes the Thermalito Afterbay and surrounding lands (approximately 6,000 acres) along with 5,000 acres adjoining the Feather River. The 5,000 acre area straddles 12 miles of the Feather River, which includes willow and cottonwood lined ponds, islands, and channels. Recreation areas include dispersed recreation (hunting, fishing, and bird watching), plus recreation at developed sites, including Monument Hill day use area, model airplane grounds, three boat launches on the Afterbay and two on the river, and two primitive camping areas. California Department of Fish and Game's (DFG) habitat enhancement program includes a wood duck nest-box program and dry land farming for nesting cover and improved wildlife forage. Limited gravel extraction also occurs in a number of locations.

1.3 CURRENT OPERATIONAL CONSTRAINTS

Operation of the Oroville Facilities varies seasonally, weekly and hourly, depending on hydrology and the objectives DWR is trying to meet. Typically, releases to the Feather River are managed to conserve water while meeting a variety of water delivery requirements, including flow, temperature, fisheries, recreation, diversion and water quality. Lake Oroville stores winter and spring runoff for release to the Feather River as necessary for project purposes. Meeting the water supply objectives of the SWP has always been the primary consideration for determining Oroville Facilities operation (within the regulatory constraints specified for flood control, in-stream fisheries, and downstream uses). Power production is scheduled within the boundaries specified by the water operations criteria noted above. Annual operations planning is conducted for multi-year carry over. The current methodology is to retain half of the Lake Oroville storage above a specific level for subsequent years. Currently, that level has been established at 1,000,000 acre-feet (af); however, this does not limit draw down of the reservoir below that level. If hydrology is drier than expected or requirements greater than expected, additional water would be released from Lake Oroville. The operations plan is updated regularly to reflect changes in hydrology and downstream operations. Typically, Lake Oroville is filled to its maximum annual level of up to 900 feet above mean sea level (msl) in June and then can be lowered as necessary to meet downstream requirements, to its minimum level in December or January. During drier years, the lake may be drawn down more and may not fill to the desired levels the following spring. Project operations are directly constrained by downstream operational constraints and flood management criteria as described below.

1.3.1 Downstream Operation

An August 1983 agreement between DWR and DFG entitled, "Agreement Concerning the Operation of the Oroville Division of the State Water Project for Management of Fish & Wildlife," sets criteria and objectives for flow and temperatures in the low flow channel and the reach of the Feather River between Thermalito Afterbay and Verona. This agreement: (1) establishes minimum flows between Thermalito Afterbay Outlet and Verona which vary by water year type; (2) requires flow changes under 2,500 cfs to be reduced by no more than 200 cfs during any 24-hour period, except for flood management, failures, etc.; (3) requires flow stability during the peak of the fall-run Chinook spawning season; and (4) sets an objective of suitable temperature conditions during the fall months for salmon and during the later spring/summer for shad and striped bass.

1.3.1.1 Instream Flow Requirements

The Oroville Facilities are operated to meet minimum flows in the Lower Feather River as established by the 1983 agreement (see above). The agreement specifies that Oroville Facilities release a minimum of 600 cfs into the Feather River from the Thermalito Diversion Dam for fisheries purposes. This is the total volume of flows from the diversion dam outlet, diversion dam power plant, and the Feather River Fish Hatchery pipeline.

Generally, the instream flow requirements below Thermalito Afterbay are 1,700 cfs from October through March, and 1,000 cfs from April through September. However, if runoff for the previous April through July period is less than 1,942,000 af (i.e., the 1911-1960 mean unimpaired runoff near Oroville), the minimum flow can be reduced to 1,200 cfs from October to February, and 1,000 cfs for March. A maximum flow of 2,500 cfs is maintained from October 15 through November 30 to prevent spawning in overbank areas that might become de-watered.

1.3.1.2 Water Temperature Requirements

The Diversion Pool provides the water supply for the Feather River Fish Hatchery. The hatchery objectives are 52°F for September, 51°F for October and November, 55°F for December through March, 51°F for April through May 15, 55°F for last half of May, 56°F for June 1-15, 60°F for June 16 through August 15, and 58°F for August 16-31. A temperature range of plus or minus 4°F is allowed for objectives, April through November.

There are several temperature objectives for the Feather River downstream of the Afterbay Outlet. During the fall months, after September 15, the temperatures must be suitable for fall-run Chinook. From May through August, they must be suitable for shad, striped bass, and other warm water fish.

The National Marine Fisheries Service has also established an explicit criterion for steelhead trout and spring-run Chinook salmon. Memorialized in a biological opinion on the effects of the Central Valley Project and SWP on Central Valley spring-run Chinook and steelhead as a reasonable and prudent measure; DWR is required to control water temperature at Feather River mile 61.6 (Robinson's Riffle in the low-flow channel) from June 1 through September 30. This measure requires water temperatures less than or equal to 65°F on a daily average. The requirement is not intended to preclude pump-back operations at the Oroville Facilities needed to assist the State of California with supplying energy during periods when the California ISO anticipates a Stage 2 or higher alert.

The hatchery and river water temperature objectives sometimes conflict with temperatures desired by agricultural diverters. Under existing agreements, DWR provides water for the Feather River Service Area (FRSA) contractors. The contractors claim a need for warmer water during spring and summer for rice germination and growth (i.e., 65°F from approximately April through mid May, and 59°F during the remainder of the growing season). There is no obligation for DWR to meet the rice water temperature goals. However, to the extent practical, DWR does use its operational flexibility to accommodate the FRSA contractor's temperature goals.

1.3.1.3 Water Diversions

Monthly irrigation diversions of up to 190,000 (July 2002) af are made from the Thermalito Complex during the May through August irrigation season. Total annual entitlement of the Butte and Sutter County agricultural users is approximately 1 maf. After meeting these local demands, flows into the lower Feather River continue into the Sacramento River and into the Sacramento-San Joaquin Delta. In the northwestern portion of the Delta, water is pumped into the North Bay Aqueduct. In the south Delta, water is diverted into Clifton Court Forebay where the water is stored until it is pumped into the California Aqueduct.

1.3.1.4 Water Quality

Flows through the Delta are maintained to meet Bay-Delta water quality standards arising from DWR's water rights permits. These standards are designed to meet several water quality objectives such as salinity, Delta outflow, river flows, and export limits. The purpose of these objectives is to attain the highest water quality, which is reasonable, considering all demands being made on the Bay-Delta waters. In particular, they protect a wide range of fish and wildlife including Chinook salmon, Delta smelt, striped bass, and the habitat of estuarine-dependent species.

1.3.2 Flood Management

The Oroville Facilities are an integral component of the flood management system for the Sacramento Valley. During the wintertime, the Oroville Facilities are operated under flood control requirements specified by the U.S. Army Corps of Engineers (USACE). Under these requirements, Lake Oroville is operated to maintain up to 750,000 af of storage space to allow for the capture of significant inflows. Flood control releases are based on the release schedule in the flood control diagram or the emergency spillway release diagram prepared by the USACE, whichever requires the greater release. Decisions regarding such releases are made in consultation with the USACE.

The flood control requirements are designed for multiple use of reservoir space. During times when flood management space is not required to accomplish flood management objectives, the reservoir space can be used for storing water. From October through March, the maximum allowable storage limit (point at which specific flood release would have to be made) varies from about 2.8 to 3.2 maf to ensure adequate space in Lake Oroville to handle flood flows. The actual encroachment demarcation is based on a wetness index, computed from accumulated basin precipitation. This allows higher levels in the reservoir when the prevailing hydrology is dry while maintaining adequate flood protection. When the wetness index is high in the basin (i.e., wetness in the watershed above Lake Oroville), the flood management space required is at its greatest amount to provide the necessary flood protection. From April through June, the maximum allowable storage limit is increased as the flooding potential decreases, which allows capture of the higher spring flows for use later in the year. During September, the maximum allowable storage decreases again to prepare for the next flood season. During flood events, actual storage may encroach into the flood reservation zone to prevent or minimize downstream flooding along the Feather River.

2.0 NEED FOR STUDY

Tasks 1D and 1E are subtasks of SP-F10, *Evaluation of Project Effects on Salmonids and their Habitat in the Feather River below the Fish Barrier Dam*. Task 1D fulfils a portion of the FERC application requirements by evaluating the effects of water temperatures on early upmigrating (spring-run) adult Chinook salmon production, while Task 1E evaluates the effects of water temperatures on adult spring-run Chinook salmon holding habitat and use patterns in the lower Feather River. In addition to fulfilling statutory requirements, information collected during this task may be used in developing or evaluating potential Resource Actions.

Performing this study is necessary, in part, because operation of the Oroville Facilities affects flows and water temperatures in the Feather River downstream of the Fish Barrier Dam (DWR 2001). Water temperature is an important factor influencing adult spring-run Chinook holding habitat. Flow and water temperature manipulations resulting from operation of the Oroville Facilities, therefore, may affect spring-run Chinook salmon production, and the quality, quantity, and distribution of spring-run Chinook salmon holding habitat below Oroville Dam. In addition, alteration in sediment recruitment in the Feather River channel below Oroville Dam may result in depletion of gravel and sand, and armoring of cobble and boulder substrates (DWR 2001). The current and future distribution of these substrate types also has the potential to affect the quality, quantity, and distribution of spring-run Chinook salmon holding habitat.

Task 1 of SP-F10 evaluates the effects of Feather River water temperatures and flows on upmigrating and holding adult Chinook salmon in the Feather River. Tasks 1A and 1C evaluate flow-related effects on upmigrating adult salmonids. Task 1A evaluates the effects of Feather River flows on attraction of upmigrating salmonids, and Task 1C evaluates the effects of flow on potential physical passage impediments to adult salmonid upmigration. Tasks 1B, 1D, and 1E evaluate the effects of water temperatures on adult salmonids. Task 1B evaluates the effect of water temperatures on attraction of upmigrating salmonid adults, while Task 1D evaluates the effects of water temperatures on pre-spawning adult salmonids and subsequent reproduction. Task 1E evaluates the effects of water temperature on adult spring-run Chinook salmon holding habitat and use patterns in the lower Feather River.

3.0 STUDY OBJECTIVE

The objectives of SP-F10 Tasks 1D and 1E are to evaluate the effects of water temperature on adult spring-run Chinook salmon production, and holding habitat and use patterns in the lower Feather River.

3.1 APPLICATION OF STUDY INFORMATION

Information obtained in this study is associated with, and will be applied to, the following purposes and activities:

3.1.1 Department of Water Resources/Stakeholders

The information from this analysis will be used by DWR and the Environmental Work Group (EWG) to evaluate potential on-going effects of project operations on water temperatures to which early upmigrating adult Chinook salmon are exposed during immigration and holding. Additionally, data collected in this task serve as a foundation for future evaluation and development of potential Resource Actions.

3.1.2 Other Studies

As a subtask of study plan SP-F10, *Evaluation of Project Effects on Salmonids and their Habitat in the Feather River below the Fish Barrier Dam,* Task 1 of SP-F10 evaluates the effects of Feather River water temperatures and flows on upmigrating and holding adult Chinook salmon in the Feather River. Tasks 1A and 1C evaluate flow-related effects on upmigrating adult salmonids. Task 1A evaluates the effects of Feather River flows on attraction of upmigrating salmonids, and Task 1C evaluates the effects of flow on potential physical passage impediments to adult salmonid upmigration. Tasks 1B, 1D, and 1E evaluate the effects of water temperatures on adult salmonids. Task 1B evaluates the effect of water temperatures on attraction of upmigrating salmonid adults, while Task 1D evaluates the effects of water temperatures on pre-spawning adult salmonids and subsequent reproduction. Task 1E evaluates the effects of water temperature on early upmigrating adult Chinook salmon holding habitat and use patterns.

3.1.3 Environmental Documentation

In addition to Section 4.51(f)(3) of 18 CFR, which requires reporting of certain types of information in the FERC application for license of major hydropower projects (FERC 2001), it may be necessary to satisfy the requirements of the National Environmental Policy Act (NEPA) as well as the Endangered Species Act (ESA). Because FERC has the authority to grant an operating license to DWR for continued operation of the Oroville Facilities, discussion is required to identify the potential impacts of the project on many types of resources, including fish, wildlife, and botanical resources. In addition, NEPA requires discussion of any anticipated continuing impact from on-going and future operations. To satisfy NEPA and ESA, DWR is preparing a Preliminary Draft Environmental Assessment (PDEA) to attach to the FERC license application, which shall include information provided by this study plan report.

3.1.4 Settlement Agreement

In addition to statutory and regulatory requirements, SP-F10 Tasks 1D and 1E provide information that may be useful in the development of potential Resource Actions to be negotiated during the collaborative process. Additionally, information obtained from analysis of the effects of water temperatures on adult spring-run Chinook salmon production, and holding habitat and use patterns in the lower Feather River could be used to identify operating procedures negotiated during the collaborative settlement process.

4.0 METHODOLOGY

4.1 STUDY DESIGN

4.1.1 Spring-Run Chinook Salmon Life History

Historically, spring-run Chinook salmon were reported to have ascended to the very highest streams and headwaters in the Feather River watershed (DFG 1998b). Currently, the Fish Barrier Dam below Oroville Dam restricts fish passage to historic spawning grounds at higher elevations (DFG 1998b). Spring-run Chinook salmon generally exhibit a stream-type life history while fall-run Chinook salmon generally exhibit an ocean-type life history (Moyle 2002). Adult salmon reportedly enter their natal tributaries as sexually immature fish and hold in the river over the summer while gonadal maturation takes place (DFG 1998b; DWR and USBR 2000; Moyle 2002). It has been reported adult spring-run Chinook salmon enter the Feather River from March through June (Sommer et al. 2001). The Chinook salmon immigration and holding period extends from the time that adult salmon reach their spawning areas until the onset of spawning, reportedly from August through October (DFG 1998b; DWR and USBR 2000; Moyle 2002). Therefore, in the Feather River, holding is assumed to occur from the time that spring-run Chinook salmon enter the river (March) through spawning (October).

4.1.2 Spring-Run Chinook Salmon Immigration and Holding Timing

Very little data exist to elucidate trends in habitat use and temporal distribution of spring-run Chinook salmon in the Feather River, partly because no consistent, long-term monitoring program has been implemented on the river. One study designed to assess the accuracy of carcass counts also assessed the timing of upmigrating Chinook salmon from 1969 through 1971. Fish longer than 26 inches total length were collected via a weir placed approximately 1.5 miles above the Thermalito Afterbay Outlet. These data show numbers of adult upmigrant Chinook salmon from August 1969 through January 1970, from August 1970 through December 1970, and from August 1971 through December 1971 (Painter et al. 1977). Due to the temporal overlap between upmigrating spring-run and fall-run Chinook salmon, these data do not specifically elucidate the temporal distribution of adult spring-run Chinook salmon migrants. Another study performed in 1968 and 1969 attempted to find hatchery holding areas where adult spring-run Chinook salmon could be successfully held over the summer. The hatchery gates were opened for various periods between May 12, 1968 and July 31, 1968 as well as between April 1 and May 20, 1969. During 1968, 90 fish were counted entering the hatchery and during 1969, 112 fish entered the hatchery. The study was not continued due to high mortality rates of holding fish in the hatchery (Painter et al. 1977). Although the study demonstrated the difficulty in holding adult Chinook salmon over the summer in the hatchery, it also showed that adult Chinook salmon have been in the vicinity of the hatchery as early as April 1. However, the short time period and lack of consistency between data collected in 1968 and 1969 do not allow for analysis of trends in adult spring-run Chinook salmon upmigrant timing.

4.1.3 Definition of Immigration and Holding Period

Adult Central Valley spring–run Chinook salmon immigration reportedly occurs from February to mid-August (Myrick and Cech Jr. 2001). The adult immigration and holding life stage is defined as the time period encompassing the time from freshwater entry until spawning site selection. In the Feather River, the Chinook salmon immigration and holding period was assumed to occur from March through October based on analysis of reported Chinook salmon arrival times in the Feather River (Sommer et al. 2001) and general dates reported for the onset of spring-run Chinook salmon spawning. Generally, it has been reported that spring-run Chinook salmon spawning occurs from mid to late August through October (DFG 1998b; DWR and USBR 2000; Moyle 2002). The end of October was used in this analysis as the end of the spring-run Chinook salmon immigration and holding period because it was assumed that all spring-run Chinook salmon have begun spawning by then. Therefore spring-run Chinook salmon would not be holding after October.

4.1.4 Habitat Requirements for Immigration and Holding

Spring-run Chinook salmon reportedly enter freshwater several months prior to spawning. Effects of flow and water temperature on spring-run Chinook salmon migration timing in the Feather River are poorly understood due to a lack of available information.

In general, Chinook salmon utilize all habitat types for travel corridors to spawning grounds if passage is possible. Therefore, holding habitat usually is the limiting factor in habitat suitability for the immigration and holding life stage of adult spring-run Chinook salmon. During the Chinook salmon immigration and holding period (March through October), pools reportedly should be sufficiently deep, cool, and oxygenated to allow over-summer survival of spring-run Chinook salmon (DWR and USBR 2000). In general, Moyle (2002) reports that spring-run Chinook salmon select pools that are usually greater than two meters (6.6 ft) deep, typically with bedrock bottoms and water velocities ranging from 15 to 80 cm/sec (0.49-2.6 ft/sec). Adult spring-run Chinook salmon reportedly utilize overhanging ledges, deep pockets, and “bubble curtains” created by high velocity inflow, as cover during the day (DFG 1998b; DWR and USBR 2000; Moyle et al. 1995; Moyle 2002). It also has been reported that holding fish utilize “pocket water” behind large rocks as velocity refuges in faster moving water (Moyle et al. 1995; Sommer et al. 2001). During the spring-run Chinook salmon immigration and holding period, adult fish reportedly do not necessarily stay in one pool throughout the summer, but move between pools, generally with a net upstream movement (Moyle 2002). Pools are generally reported to be located near spawning areas, which may be at the tails of holding pools (DFG 1998b; DWR and USBR 2000; Moyle 2002).

4.1.5 Pool Selection Criteria

Study Plan F10 called for substrate classification, dissolved oxygen concentration, and water temperature data to be collected from pools within the lower Feather River. During data collection activities for SP-G2, habitat types within the study area downstream of the Fish Barrier Dam were characterized and mapped. Defining characteristics of pools included relatively low gradient, with substrate of fine materials, relatively low water velocities, relatively high depth, tranquil flow, and section-controlled geomorphology. Pools sampled in the Feather River exhibited these characteristics, although many of them did not have a "scoured bowl" shape that is often considered typical holding habitat for adult spring-run Chinook salmon (pers. comm., S. McReynolds 2003)).

4.1.6 Definition of Suitable Substrate for Adult Spring-run Chinook Salmon Immigration and Holding

No available studies have attempted to characterize migratory requirements and identify those physical factors such as suitable substrate that exert significant influence on the spawning upmigration timing, spatial distribution, and abundance of adult spring-run Chinook salmon. Additionally, little data exist describing the composition of suitable substrates for upmigrating and holding adult spring-run Chinook salmon. Chinook salmon reportedly hold in pools characterized by depths of 3.3 ft to 9.8 ft with bedrock substrate (Moyle 2002). DFG (1998b) suggests that adult spring-run Chinook salmon prefer deep pools that have bedrock bottoms and that holding salmon tend to avoid cobble, gravel, sand, and silt substrates. Others suggest that although holding pools generally have bedrock bottoms, but that suitable holding habitat generally depends on the pool volume, pool depth, amount of available cover, and proximity to spawning gravel (Moyle et al. 1995).

Based on the current and historic distribution of holding spring-run Chinook salmon populations, it is possible that reported substrate preferences were simply observations of habitat utilization rather than actual descriptions of preferred substrate types. Adult spring-run Chinook salmon historically held in the headwaters of natal stream systems and current distribution information suggests that they migrate as far upstream as possible before holding (DFG 1998b). Oftentimes those reaches are located in bedrock canyons. It has been reported, for example, that the reach in Butte Creek in which holding occurs, suitable water temperatures, and velocities occur in pools, which also have bedrock bottoms (Butte Creek Watershed Conservancy Website). Therefore, it is not possible to definitively determine a causal relationship between substrate composition and holding pool preference because of the influence of other explanatory variables such as water temperature.

Because of a lack of definitive evidence to suggest that substrate composition is a defining factor in habitat suitability for holding adult spring-run Chinook salmon, the substrate composition data collected by SP-G2 were not analyzed to determine suitability of pools for holding in the Feather River.

4.1.7 Definition of Suitable Cover for Adult Spring-run Chinook Salmon Immigration and Holding

Because immigrating adult spring-run Chinook salmon do not eat and have no natural predators once they begin upstream migration (DFG 1998b; DWR and USBR 2000), it is not known to what extent cover is important, however Moyle and others report that suitable cover is required for spring-run Chinook salmon holding habitat (DFG 1998b; DWR and USBR 2000; Moyle et al. 1995; Moyle 2002). It has been reported that holding Chinook salmon use pocket water as velocity refuges and seek shade under rocky ledges while holding (Moyle et al. 1995; Moyle 2002). In holding areas where velocities are low enough such that salmon need not seek refuge, and where water temperatures are cool enough to sufficiently slow metabolic activity, it is possible that cover is not a requirement for holding pool suitability.

Holding pools reportedly usually have a large bubble curtain at the head, underwater rocky ledges, and shade cover throughout the day (Moyle et al. 1995). In the Feather River, few pools exist with the types of cover (bubble curtains, rocky ledges, pocket water, etc.) described in the literature as preferred by holding spring-run Chinook salmon. Because spring-run Chinook salmon do hold in the Feather River, it is necessary to determine whether correlations exist between cover availability and habitat use. Unfortunately no cover data were ever available, limiting the type of analysis that could be performed for this report.

4.1.8 Definition of Suitable water Velocities for Adult Spring-run Chinook Salmon Immigration and Holding

In general, Chinook salmon utilize all habitat types for travel corridors to spawning grounds if passage is possible. Therefore, holding habitat usually is the limiting factor in habitat suitability for the immigration and holding life stage of adult spring-run Chinook salmon. Low stream flows may affect or impede adult salmon on their upstream migration to spawning areas (Bjornn and Reiser 1991). Additionally, instream flow is directly related to water velocities encountered during immigration and holding. Differences in instream flow needs have been reported for salmonids in Northern California. Generally, pacific salmon are divided into two groups with respect to their instream flow requirements and preferences. The high-flow guild reportedly includes Chinook salmon, pink salmon, and chum salmon, whereas the low-flow guild includes coho and sockeye salmon (Vadas 2000).

Water velocities in appropriate holding habitat reportedly range from 0.5 ft/sec to 2.6 ft/sec (DWR and USBR 2000; Moyle et al. 1995; Moyle 2002). Suitable water velocities are reported to be an important criterion in determining suitable holding pool habitat. A range of 0.5 to 1.3 ft/sec has been reported by (DFG 1998b; DWR and USBR 2000). Moyle (2002) reports that in California, spring-run Chinook salmon usually hold in water column velocities between 15 and 80 cm/sec (0.49-2.6 ft/sec). Moyle and others (1995) reported that in Deer Creek, Tehama County, in 1988, holding adult spring-run Chinook salmon preferred water velocities between 60 and 80 cm/sec (2-2.6 ft/sec). Additionally, Moyle et al. (1995) reported that other authors suggest that optimal holding velocity ranges between 15 and 37 cm/sec (0.49-1.2 ft/sec).

It is unknown whether pools within the Feather River contain suitable velocities for holding adult Chinook salmon.

4.1.9 Definition of Suitable Water Temperatures for holding Spring-Run Chinook Salmon

4.1.9.1 Interim Report Water Temperature Index Values

In order to identify and characterize spring-run Chinook salmon holding habitat a literature review was conducted to determine suitable water temperatures for pre-spawning adults. DFG (1998) suggested that... “the upper limit of the optimal temperature range for adults holding while eggs are maturing is 59°F to 60°F (Hinze 1959)”. These water temperatures correspond to 15°C (59°F) to 15.6°C (60°F). However, detailed examination of Hinze (1959) revealed that the study did not specifically address water temperature requirements for holding adult spring-run Chinook salmon. Rather, Hinze (1959) examined variable water temperature exposures to adults and incubating eggs of fall-run Chinook salmon, and reported survival rates of the eggs. Conventional salmon hatchery practice is reported to consider salmon brood stocks thermally stressed above 15°C (59°F) (McCullough 1999). In the extensive literature review of the effects of changes in water temperature regime on various life stages of Chinook salmon, McCullough (1999) presented evidence that thermal stress caused increased adult mortality, increased incidence of disease among adults, and increased egg mortality for progeny of adults holding in elevated water temperatures. Reportedly, laboratory tests confirm that water temperatures above 21°C (69.8°F) equal or exceed incipient lethal water temperatures for Columbia River Chinook salmon stocks immigrating in the summer (McCullough 1999). Berman (1990) *in* McCullough (1999) reported no mortality from Columnaris disease in spring-run Chinook salmon taken from the Yakima River and held for 1.5 months at 14°C (57.2°F), while 100 percent mortality from infection was reported in those fish held at 19°C (66.2°F). In a subsequent experiment, Berman (1990) *in* McCullough (1999) showed that pre-spawning adults that were held between 17.5°C (63.5°F) and 19°C (66.2°F) for two weeks prior to spawning had increased pre-hatch mortality and decreased alevin size compared to a control group held between 14.5°C (58.1°F) and 15°C (59°F). Williams et al. (2002) reported that there is evidence that the historic population of spring-run Chinook salmon in the San Joaquin River was unusually tolerant of high water temperatures and that they held in pools with water temperatures that reached 22.7°C (72.9°F). Based on the output of a habitat suitability index model, Raleigh et al. (1986) suggested that the maximum suitability for pre-spawning adult Chinook salmon occurs when water temperatures range between 8°C (46.4°F) and 12°C (53.6°F) (Raleigh et al. 1986). Marine (1992) reported water temperature ranges for a variety of effects on adult Chinook salmon. A range of 6°C (42.8°F) to 14°C (57.2°F) was reported for optimal pre-spawning brood stock survival, maturation, and spawning (Marine 1992). It has been suggested, however, that spring-run Chinook salmon in Butte Creek routinely hold in pools with mean daily water temperatures that often exceed 20.0°C (68°F) (Williams et al. 2002). Mean water temperatures in spring-run Chinook salmon holding pools in Mill Creek, Tehama County, was reported to be 20°C (68°F) with a range of 18.3°C to 21.1°C (65°F to 70°F) during the summer of 1986 (Moyle et al. 1995).

Due to the wide range of reported suitable water temperatures for adult spring-run Chinook salmon holding, selection of a single water temperature value to which collected data could be compared would be imprudent. Marine (1992) performed a literature search in conjunction with extensive interviews of hatchery managers and agency personnel, and concluded that sublethal effects of chronic pre-spawning exposure to elevated water temperatures on reproductive performance may likely begin to occur within the water temperature range of 15°C to 17°C (59°F to 62.6°F). In addition, Marine (1992) concluded that for chronic exposures, an upper incipient lethal water temperature limit for pre-spawning adult Chinook salmon probably falls within the range of 17°C to 20°C (62.6°F to 68°F). Values reported by Marine (1992) were chosen as the basis for analysis of potentially suitable holding pools for adult spring-run Chinook salmon in the Feather River. Marine (1992) provided a water temperature range reported as optimal for survival, maturation and spawning, a range in which sublethal effects of chronic exposure could occur, and a range in which approximately 50 percent of an exposed population would die (incipient upper lethal water temperatures). In addition, Marine (1992) interviewed hatchery and agency personnel in the Sacramento River basin and in other parts of California; thus, the reported water temperature ranges may be more representative of effects to Feather River fish than those water temperatures provided in the literature for fish in other latitudes, such as the Yakima River in Washington, reported in McCullough (1999). Bell (1991) indicated that latitudinal differences in water temperature tolerances were approximately equal to one degree F for each degree change in latitude. Due to the range of water temperatures reported by Marine (1992), the endpoints of the range (e.g., 15°C and 17°C (59°F and 62.6°F) for sublethal effects of chronic exposure) were used as indicators at which effects could potentially occur to adult Chinook salmon holding in the Feather River. The resultant water temperature indices were compared to data collected by DWR to identify and characterize potential holding habitat within the Feather River.

4.1.9.2 Final Report Water Temperature Index Values

Water temperature index values were selected against which observed water temperatures could be compared to determine the potential effects on Chinook salmon immigration and holding. The water temperature index values were selected from available literature to reflect an evenly spaced range of water temperatures that provide conditions reportedly ranging from optimal to lethal. Types of literature examined include: scientific journals, Master's theses and PhD dissertations, literature reviews, and agency publications. With respect to water temperature, the primary concern in the Central Valley relates to water temperatures that may exceed upper salmonid thermal tolerance limits rather than lower limits. Therefore, index values were only established for elevated water temperatures. Water temperature index values were determined by placing emphasis on the results of laboratory experiments that examined how water temperature affects Central Valley Chinook salmon as well as by considering regulatory documents, such as Biological Opinions from NOAA Fisheries. Studies on fish from outside the Central Valley were used to establish index values when local studies were unavailable. Studies conducted on Chinook salmon from stocks originating outside the Central Valley were used to establish index values when local studies were unavailable. To avoid unwarranted specificity, only whole integers were selected as index values. Thus support for index values was, in some cases, partially derived from literature supporting a water temperature that varied from the resultant index value by several tenths of a degree. Rounding for the purposes of selecting index values is appropriate because the daily variation of experimental treatment water temperatures often is high. For example, latent embryonic mortalities and abnormalities reportedly occur when pre-spawning adult Chinook salmon are exposed to water temperatures from 63.5°F to 66.2°F (Berman 1990). Additionally, EPA (2003) reports disease risk becomes higher in pre-spawning adult Chinook salmon when water temperatures rise above 64.4°F. In order to accurately represent the effects described by Berman (1990) and EPA (2003) an index value of 64°F (17.8°C) was chosen. For a detailed explanation of the rationale for selecting water temperature indices, see **Appendix F**.

Most of the available literature on salmonid water temperature requirements refers to "stressful", "tolerable", "preferred", or "optimal" water temperatures or water temperature ranges. Spence et al. (1996) defined the tolerable water temperature range as the range at which fish can survive indefinitely. Stressful water temperatures alter the biological functions of individual fish and decrease the probability of survival (McCullough 1999). Optimal water temperatures provide for feeding activity, normal physiological response, and behavior void of thermal stress symptoms (McCullough 1999). Preferred water temperature ranges are those that are most frequently selected by fish when allowed to freely choose locations along a thermal gradient (McCullough 1999). Properly functioning condition (PFC) is an additional term describing habitat that was defined by NOAA Fisheries *in* McElhany et al. (2000) as, "…freshwater spawning and rearing conditions necessary for the long-term survival of Pacific salmon populations."

Because water temperature index values were utilized as technical evaluation guidelines, the terms used in the analysis presented in the Interim Report, such as optimal, suitable, unsuitable, sublethal, or lethal when referring to water temperatures were no longer used in the Final Report for SP-F10 Tasks 1D and 1E (Final Report), herein. The analysis conducted for this report includes reporting the percentages, or proportions, of water temperature data exceeding each of the water temperature index values. The physiological effects reported for the range of water temperatures associated with each of the water temperature index values are presented in Table 4.1-1 and in Appendix F.

One set of adult immigration and holding water temperature index values was established for all Chinook salmon run-types collectively because available literature often did not differentiate between run types. The water temperature index values selected to evaluate the Chinook salmon adult immigration and holding life stage are: 60°F (15.6°C), 64°F (17.8°C), and 68°F (20°C) (Table 4.1-1). Although 56°F (13.3°C) is referenced in the literature frequently as the upper water temperature limit required for upstream migration and holding, the references are not foundational studies and often are inappropriate citations. For example, many of the references to 56°F (13.3°C) are based on Hinze (1959), which is a study examining the effects of water temperature on incubating Chinook salmon eggs. Boles et al. (1988), Marine (1992), and NOAA Fisheries (1997b) all cite Hinze (1959) in support of recommendations for a water temperature of 56°F (13.3°C) for Chinook salmon upmigration. Because 56°F (13.3°C) is not strongly supported in the literature, it was not selected as an index value. The lowest index value selected was 60°F (15.6°C), because in the NOAA Fisheries biological opinion for the proposed operation of the Central Valley Project and State Water Project, 59°F (15°C) to 60°F (15.6°C) is reported as, “The upper limit of the optimal temperature range for adults holding while eggs are maturing (NOAA Fisheries 2000).” NOAA Fisheries (1997b) states, “Generally, the maximum temperature of adults holding, while eggs are maturing, is about 59°F (15°C) to 60°F (15.6°C)" and that the, “Acceptable range for adults upmigrating upstream range from 57°F (13.9°C) to 67°F (19.4°C)”. ODEQ (1995) reports that, “…many of the diseases that commonly affect Chinook become highly infectious and virulent above 60°F (15.6°C).” Additionally, 64°F (17.8°C) was chosen as an index value, because Berman (1990) suggested that effects of thermal stress to pre-spawning adults are evident at water temperatures near 64°F (17.8°C) and also because 64°F (17.8°C) represents a mid-point value between the water temperature index values of 60°F (15.6°C) and 68°F (20°C). Berman (1990) conducted a laboratory study to determine if pre-spawning water temperatures experienced by adult Chinook salmon influenced reproductive success, and found evidence suggesting latent embryonic abnormalities associated with water temperature exposure to pre-spawning adults occurs at 63.5°F (17.5°C) to 66.2°F (19°C). The highest water temperature index value chosen was 68°F (20°C) because available literature suggests that thermal stress at water temperatures greater than or equal to 68°F (20°C) is pronounced and severe adverse effects to upmigrating and holding pre-spawning adults, including mortality can be expected (Berman 1990; Marine 1992; NOAA Fisheries 1997a). Because significant impacts to upmigrating and holding adult Chinook salmon reportedly occur at water temperatures greater than or equal to 68°F (20°C), it was not necessary to select index values higher than 68°F (20°C).

Based on available scientific literature and regulatory agency documents, the water temperature index values for spring-run Chinook salmon immigration and holding are shown in Table 4.1-1.

Table 4.1-1. Water temperature index values for the immigration and holding life stage of Chinook salmon.

Water Temperature Index Values	Rationale
60°F (15.6°C)	Maximum water temperature suitable for adults holding, while eggs are maturing, is approximately 59°F to 60°F (NOAA Fisheries 1997a); Acceptable water temperatures for adults migrating upstream range from 57°F to 67°F (NOAA Fisheries 1997a); Upper limit of the optimal water temperature range for adults holding while eggs are maturing is 59°F to 60°F (NOAA Fisheries 2000); Many of the diseases that commonly affect Chinook salmon become highly infectious and virulent above 60°F (ODEQ 1995); Mature females subjected to prolonged exposure to water temperatures above 60°F have poor survival rates and produce less viable eggs than females exposed to lower water temperatures (USFWS 1995)
64°F (17.8°C)	Acceptable water temperatures for adults migrating upstream range from 57°F to 67°F (NOAA Fisheries 1997a); Disease risk becomes high at water temperatures above 64.4°F (EPA 2003); Latent embryonic mortalities and abnormalities associated with water temperature exposure to pre-spawning adults occur at 63.5°F to 66.2°F (Berman 1990)
68°F (20°C)	Acceptable water temperatures for adults upmigrating upstream range from 57 to 67°F (NOAA Fisheries 1997a); For chronic exposures, an incipient upper lethal water temperature limit for pre-spawning adult salmon probably falls within the range of 62.6°F to 68.0°F (Marine 1992); Spring-run chinook salmon embryos from adults held at 63.5°F to 66.2°F had greater numbers of pre-hatch mortalities and developmental abnormalities than embryos from adults held at 57.2°F to 59.9°F (Berman 1990); Water temperatures of 68°F resulted in nearly 100 percent mortality of Chinook salmon during columnaris outbreaks (Ordal and Pacha 1963)

Based on the available literature, adverse effects associated with elevated water temperatures include: possible increased mortality rates among those adult Chinook salmon holding in freshwater during the warmest part of the summer, potential increases in pre-hatch mortality rates, potential increases in developmental abnormalities, potentially smaller eggs and alevins, potential reduction in disease resistance, potential increased disease virulence, and potential increased incidence of disease among adults. Additionally, migration barriers reportedly can occur at water temperatures of 21°C (70°F) (McCullough 1999; ODEQ 1995).

4.1.9.3 Purpose and Rationale for Separating Chinook Salmon Adult Immigration and Adult Holding Life Stages

The adult immigration and adult holding life stages were evaluated together while establishing water temperature index values, because during impacts analyses, it is difficult to determine the thermal regime to which Chinook salmon have been exposed during immigration prior to spawning. Additionally, in order to be sufficiently protective of pre-spawning Chinook salmon, water temperatures that provide high adult survival and high egg viability should be available throughout the entire freshwater immigration and holding period. Although studies examining the effects of thermal stress on immigrating Chinook salmon are rare, it has been demonstrated that thermal stress during the upstream spawning migration of sockeye salmon negatively affected the secretion of hormones controlling sexual maturation causing numerous reproductive impairments (Macdonald et al. in press *in* McCullough et al. (2001)).

4.1.10 Definition of Suitable Dissolved Oxygen for Adult Spring-run Chinook Salmon Upmigrating and Holding

4.1.10.1 Interim report

Although suitable dissolved oxygen concentration ranges have not been specifically reported for upmigrating and holding adult spring-run Chinook salmon, the EPA reports that the thirty-day mean water column dissolved oxygen concentration for protection of adult life stages of coldwater fish species is 6.5 mg/L (EPA 2002). The thirty-day mean value was used because it is the most conservative value provided for post-juvenile life stages. Single-day minimum (4.0 mg/L) and seven-day mean minimum (3.0 mg/L) criteria were both less stringent than the thirty-day mean value provided by the EPA as minimum dissolved oxygen concentrations suitable for coldwater aquatic life (EPA 2002). Therefore, for the purpose of this analysis, dissolved oxygen concentrations exceeding 6.5 mg/L were considered suitable for adult spring-run Chinook salmon holding.

4.1.10.2 Final Report

No dissolved oxygen concentration criterion was required to evaluate in-river dissolved oxygen concentrations in the Final Report of SP-F10 Tasks 1D and 1E because there dissolved oxygen concentrations never fell below the EPA criterion of 6.5 mg/L used to determine suitability in the Interim Report. Therefore dissolved oxygen concentration was not evaluated in this analysis.

4.1.11 Evaluation of the Original study plan

Potential holding pools between the Thermalito Diversion Dam and Honcut Creek were to be identified using existing DWR habitat maps. Because previous observations suggested that most adult early upmigrant Chinook salmon hold in the three miles of the Feather River immediately downstream from the Fish Barrier Dam (DWR and USBR 2000), the water temperature profile of every pool from the Thermalito Diversion Dam (RM 67) to Mathews Riffle (RM 64) was to be determined during the first year of data collection. The Thermalito Diversion Dam was chosen as the upstream extent of holding habitat characterization because of the potential to allow salmonids to hold in the Fish Barrier Pool if the habitat upstream to the Thermalito Diversion Dam is suitable for holding. Water temperatures in the lower portion (i.e. below Mathews Riffle) of the reach that extends from the Thermalito Diversion Dam to the Thermalito Afterbay Outlet (RM 59) are generally warmer than the water temperatures in the upper portion of this reach (DWR and USBR 2000). Because holding habitat in downstream from Mathews Riffle may be less suitable for adult Chinook salmon holding than the upstream portion of the reach water temperature profiles in half of the pools (50 percent) in the reach between Mathews Riffle and the Thermalito Afterbay Outlet were to be determined initially. The pools were to be stratified according to dimensions and a random sample was to be taken within each stratum. If there were not sufficient differences in pool dimensions to allow for stratification, the selection of pools was to be random within this reach. Because water releases from the Thermalito Afterbay cause warmer water temperatures downstream of the Thermalito Afterbay Outlet, the most suitable holding habitats are likely upstream of the Thermalito Afterbay Outlet (DWR and USBR 2000). Based on water temperature modeling efforts conducted on the Feather River for DWR and USBR (2000), it was concluded that for 2000 and 2001, it was unlikely that adult Chinook salmon would use the portion of the Feather River below the Thermalito Afterbay Outlet except as a migration corridor to the upper reaches of the river. However, fieldwork was initiated to determine whether or not the pools downstream of the Thermalito Afterbay Outlet do provide water temperatures suitable for holding adult Chinook salmon. Pools were to be identified and placed into strata according to pool dimensions as described above, and initially 25 percent of the pools between the Thermalito Afterbay Outlet and Honcut Creek were to be sampled according to random selection within each stratum. The same pools were to be sampled each month throughout the first field season.

After the first year of study, results were to be summarized and evaluated to determine if the level of survey effort should be re-focused. For example, if initial results suggested that water temperatures are suitable in all deep pools upstream of Mathews Riffle throughout the summer, the following field season fewer pools upstream of Mathews Riffle could be sampled and more effort could be focused on investigating pools downstream where water temperatures likely are closer to the water temperature ranges reported to have effects on holding adult Chinook salmon.

Upon selection of the pools, water temperatures were to be measured at half-meter intervals in deep pools bi-weekly from March through October. In addition to characterization of water temperatures, substrate and cover data were to be collected during the first water temperature survey of the year. Dominant substrate size was to be assessed visually using the Brusven index system currently in use by DWR (see Table 1, Task 3A of SP-F10). Cover data were also to be collected during the snorkel surveys using the currently used DWR cover codes (see SP-F10, section 7.0 Coordination and Implementation under SP-G2).

Modification in data collection methodology from the original study plan was due, in part, to the limitations in the mesohabitat maps that were to be used to select sample pools in 2002 (for the Interim Report). Prior to the first sampling effort, pools below Mathews Riffle were to be stratified using various criteria including size and depth and randomly based on that stratification. Mesohabitat maps produced by SP-G2 were to be used to stratify pools by size. Difficulty obtaining current mesohabitat maps along with a lack of data on depth and pool size precluded stratification prior to sampling. A mesohabitat map produced in 1999 by DWR was examined to determine the feasibility of substituting it for more current maps. It was determined, however, that it would be infeasible to use maps produced in 1999 due to the lack of information regarding pool depth and potential limitations associated with using outdated maps or maps inconsistent with other FERC relicensing plans (i.e., SP-G2). Thus, DWR personnel used their best professional opinion to select pools from which to collect data.

Prior to data collection in 2002, within the reach that extends from the Fish Barrier Dam to Mathews Riffle, four pools were selected for sampling. Between Mathews Riffle and the Thermalito Afterbay Outlet, two pools were sampled. Between the Thermalito Afterbay Outlet and Honcut Creek, five pools were selected, and downstream from Honcut Creek, five pools were sampled. Substrate and cover data were not collected for any of the sixteen pools that were sampled.

A potential limitation of the original study plan design includes the temporal resolution of the water temperature data set. Collection of water temperature data biweekly may not provide an accurate reflection of the overall suitability of holding habitat in the river. Biweekly data collection may not provide a representative water temperature profile during times when flows are changed during the warmest months of the summer when holding occurs, and may not be representative of actual mean monthly water temperatures. Therefore, thermographs were installed in 24 pools between the Fish Barrier Dam and Honcut Creek to allow for a more accurate representation of daily water temperatures during the 2003 spring-run Chinook salmon immigration and holding period. Figures 4.1-1 and 4.1-2 show the locations of pool profile and pool thermograph sample locations within the lower Feather River. Additionally, Interim Report indicated that no thermal stratification occurred. Therefore it was assumed that thermograph water temperature data could be a surrogate for mean daily water column temperatures.

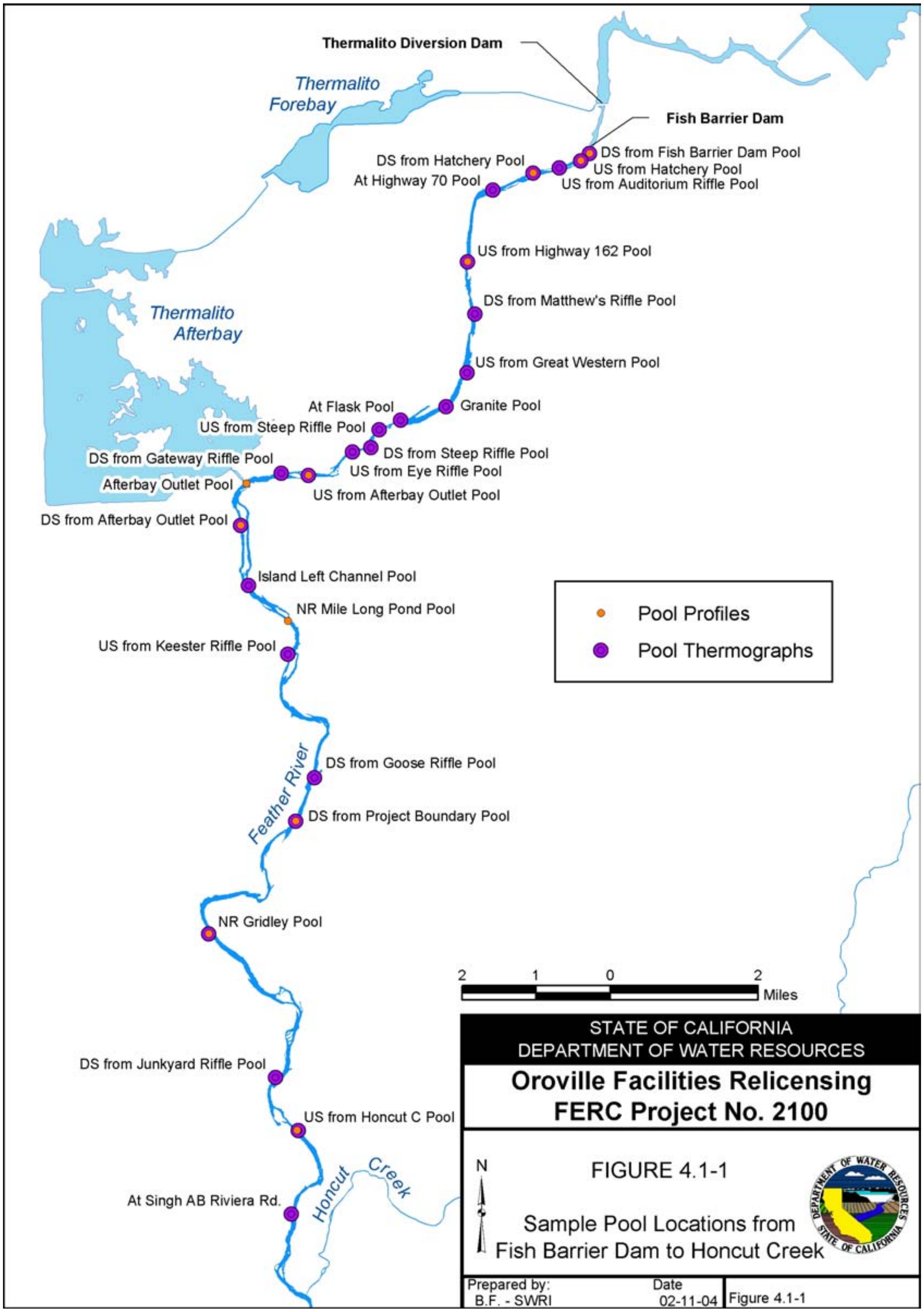

Figure 4.1-1. Sample pool locations in the lower Feather River from the Fish Barrier Dam to Honcut Creek.

Note: Pool profiles were stations sampled in 2002 and 2003. Pool thermograph stations were sampled in 2003.

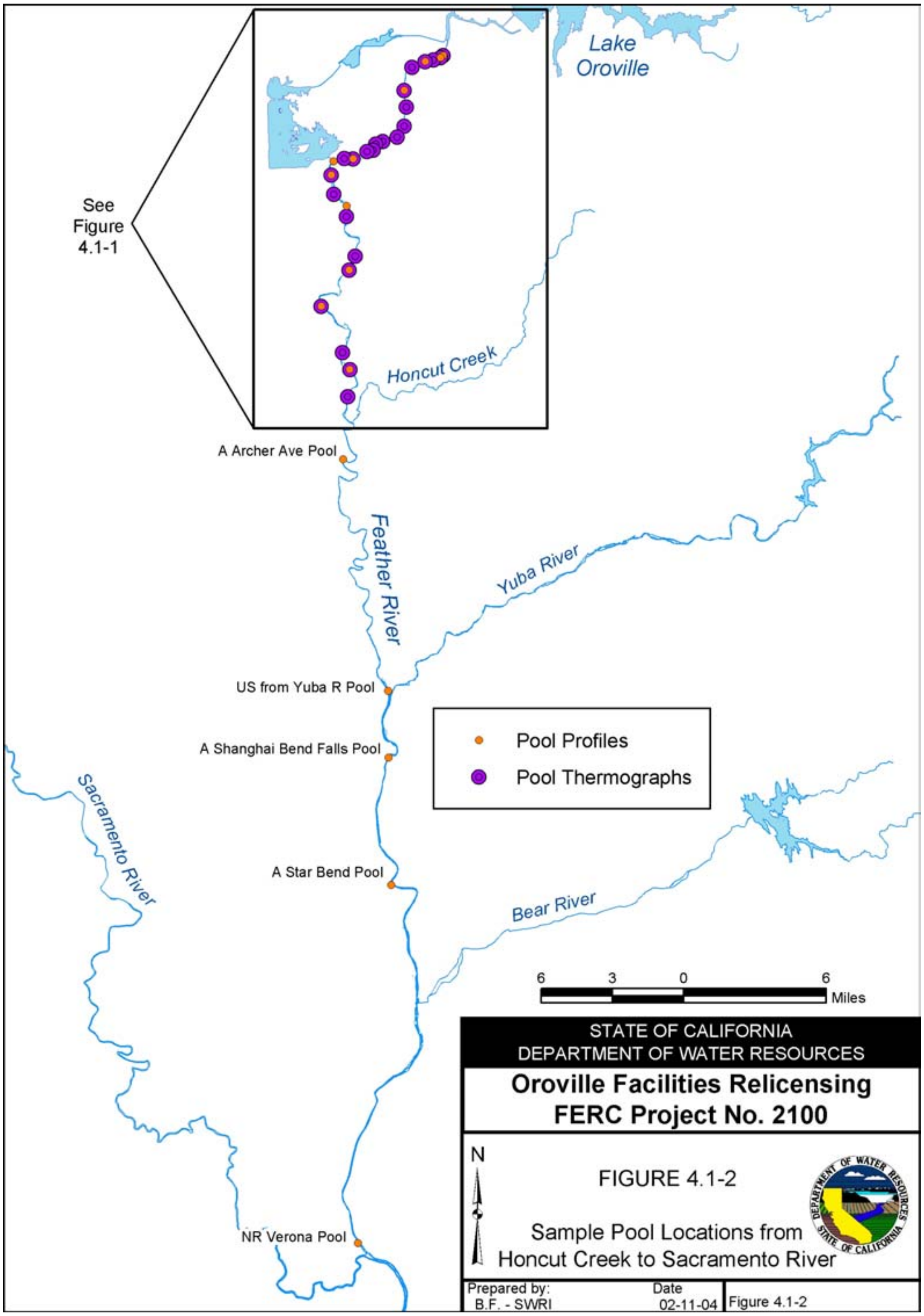

Figure 4.1-2. Sample pool locations in the lower Feather River from Honcut Creek to the confluence with the Sacramento River.
Note: Pool profiles were stations sampled in 2002 and 2003. Pool thermographs stations were sampled in 2003.

Radio tracking data was to be utilized to determine habitat use patterns for the 2003 and 2003 spring-run Chinook salmon immigration and holding periods and is presented in a separate report (*Interim Report on Pre-Spawning Chinook Salmon Migration Patterns and Holding Characteristics, SP-F10 Task 1E)* produced by DWR.

4.1.12 Methodology Comparison Between Interim and Final Report

The changes in water temperature collection methodology between the Interim Report and the Final Report were implemented due to a lack of observed thermal stratification in the deep pools in the lower Feather River. Pool profile water temperature data presented in the Interim Report indicated that thermal stratification did not occur in the pools sampled during the 2002 spring-run Chinook salmon immigration and holding period. Therefore, water temperature data collection could be performed using thermographs located in one location within a pool. The deepest parts of each pool were chosen as the locations in which to locate thermographs because, although no stratification was evident, there was a slight water temperature gradient within the water column of most pools with the coolest water temperatures collected at the bottom of each pool. However, in order to facilitate comparison of data collected in 2002 and 2003, pool profile water temperature data were collected in the same pools during the both sampling periods.

4.2 HOW AND WHERE THE STUDIES WERE CONDUCTED

The upstream extent of the study area for this evaluation is the Thermalito Diversion Dam, and the downstream extent of the study area is the confluence of the Feather and Sacramento rivers, which represents the geographic range within the Feather River that could potentially be used as holding habitat by adult spring-run Chinook salmon prior to spawning in the Feather River. The reach of the study area from the Thermalito Diversion Dam to the Fish Barrier Dam consists of the Fish Barrier Pool. The reach of the Feather River extending from the Fish Barrier Dam to the Sacramento River is composed of two operationally distinct segments. The upstream segment extends from the Fish Barrier Dam at river mile (RM) 67.25 to the Thermalito Afterbay Outlet (RM 59), while the downstream segment extends from the Thermalito Afterbay Outlet (RM 59) to the confluence of the Feather and Sacramento Rivers (RM 0).

For the purpose of analyzing pool profile water temperature data collected during the 2002 (presented in the Interim Report and Final Report) and 2003 (presented in the Final Report) sampling periods, the study area was broken down into four reaches: Reach 1 extended from the Fish Barrier Dam to Mathews Riffle (RM 67 to RM 64); Reach 2 extended from Mathews Riffle to Thermalito Afterbay Outlet (RM 64 to RM 59); Reach 3 extended from the Thermalito Afterbay Outlet to Honcut Creek (RM 59 to RM 44); and Reach 4 extended from Honcut Creek to the confluence of the Feather River with the Sacramento River (RM 44 to RM 0). Within each reach, pools were labeled numerically from upstream to downstream. For example, the most upstream pool that was sampled was designated Pool 1-1 while the most downstream pool for which data were collected was designated Pool 4-5.

For the purpose of analyzing the thermograph water temperature data collected in 2003 and presented only in the Final Report, pool names were utilized rather than assigning an artificial numbering system. The nomenclature used for the analysis of the thermograph water temperature data was different than that used for the pool profile water temperature data because thermographs were installed in 24 pools in 2003 while water temperature profile data were collected from only 16 pools in 2002 and 2003. It should be noted that both thermograph data and pool profile data were collected from nine pools. Table 4-1 indicates the pools for which pool profile and pool thermograph data were obtained.

Table 4.2-1: Pools for which thermograph and pool profile data were obtained

Pool Name	Pool Number
Feather River DS from Fish Barrier Dam Pool	1-1
Feather River US from Hatchery Pool	1-2
Feather R DS from Hatchery Pool	1-3
Feather R US from Highway 162 Pool	1-4
Feather R US from Afterbay Outlet Pool	2-1
Feather R DS from Afterbay Outlet Pool	3-1
Feather R DS from Project Boundary Pool	3-3
Feather R Near Gridley Pool	3-4
Feather R US from Honcut C Pool	3-5

4.2.1 Water Temperature

4.2.1.1 Interim Report

During sampling efforts conducted in 2002, the results of which were initially reported in the Interim Report, water temperature sampling was performed in potential spring-run Chinook salmon holding pools within the Feather River. During the spring-run Chinook salmon immigration and holding period, water temperature and water depth data were collected from April 30, 2002 through October 25, 2002. A portion of the data was lost during field activities. Table 5.1-1 shows the dates and locations for which water temperature and water depth data were available. Biweekly data existed for the period from late April 2002 through October 2002 for the three most upstream pools sampled, all of which are located within the reach from the Thermalito Diversion Dam to the Thermalito Afterbay Outlet upstream from Mathews Riffle (Reach 1). Date existed for all pool locations downstream from Highway 162 including the pool labeled “Upstream from HWY 162 Bridge Pool” (Pool 1-4) from August 2002 through October 25, 2002. Pools downstream from and including the pool labeled “Upstream from Yuba River Pool” (Pool 4-2) were sampled on three dates in August 2002, and on two dates in both September and October 2002. The sampled pools were selected by searching for the deepest pools at locations that were near DWR’s water quality and/or water temperature recorder locations on the Feather River (pers. comm., S. McReynolds 2003). In cases where no distinct deep pools were located near water quality and/or water temperature recorders, habitat types were sampled that had similar characteristics to deep pools (pers. comm., S. McReynolds 2003).

A typical sampling event during the spring and early fall months began at Verona and continued upstream to the Fish Barrier Dam on the Feather River, a stretch of river that could be covered in one day during the spring and fall due to sufficient daylight into the early evening. During the time of year when days were shorter, DWR field crews usually ascended the river to the Near Mile Long Pond Pool (Pool 3-2) or the Afterbay Outlet Pool (Pool 2-2). The remaining locations were sampled the following morning upstream from the last station monitored on the previous day. Sampling was completed using a YSI Model 550 Dissolved Oxygen/Temperature meter with a seven-meter cable and a USGS Columbus Type Sounding Weight. The probe was attached to the approximately 15-pound sounding weight and lowered to a depth of 0.5 meters for an initial reading. The meter was calibrated at the first station sampled on each day by performing a Winkler titration for dissolved oxygen (mg/L). Once calibrated, the dissolved oxygen probe was brought up to approximately two inches below the water surface. Water temperature and dissolved oxygen were then recorded in a write-in-the-rain notebook. Subsequent readings were recorded in 0.5-meter increments until the bottom of the pool was reached (pers. comm., S. McReynolds 2003).

4.2.1.2 Final Report

During sampling efforts conducted in 2003, pool profile water temperature sampling was performed at the same potential spring-run Chinook salmon holding pools within the Feather River as those sampled in 2002. During the spring-run Chinook salmon immigration and holding period, water temperature profile data were collected from March 20, 2003 through October 2, 2003.

Pool thermograph water temperature data were collected from 24 pools. Of those 24 pools, pool profile data also were collected in nine pools. Thermograph water temperature data were obtained with water temperature data loggers or thermographs, which were installed in an 8-inch long x 2-inch diameter pipes attached to the stream bank by a cable. Thermograph data represent single point location water temperatures only (usually on the bottom of a pool). To adequately measure the daily mean water temperatures, water temperature data were recorded every 15 minutes yielding 96 data points per day, which were averaged to estimate the daily mean water temperatures in each pool. Thermograph data collection began in late spring (June) and lasted until the beginning of fall (October). Portions of the thermograph time series data were lost due to equipment malfunction, thermographs becoming dewatered, or vandalism. Water temperature data for the pools sampled are represented in **Appendix A**.

4.2.2 Dissolved Oxygen Concentration

4.2.2.1 Interim Report

During sampling efforts in 2002, dissolved oxygen data were collected from April 30, 2002 through October 25, 2002. Generally Dissolved oxygen data exist for all dates and locations where water temperature and water depth data exist with the exception of the May 16, 2002 sampling date. On that date, the dissolved oxygen meter failed to calibrate properly and dissolved oxygen data were not collected. Dissolved oxygen concentration data are presented in **Appendix D**. Biweekly data exist for the period from late April 2002 through October 2002 for the three most upstream pools sampled, all of which are located within the reach from the Thermalito Diversion Dam to the Thermalito Afterbay Outlet upstream from Mathews Riffle (Reach 1). Data existed for all pool locations downstream from Highway 162 including the pool labeled “Upstream from HWY 162 Bridge Pool” (Pool 1-4) from August 2002 through October 25, 2002. Pools downstream from and including the pool labeled “Upstream from Yuba River Pool” (Pool 4-2) were sampled on three dates in August 2002, and on two dates in both September and October 2002. The sampled pools were selected by searching for the deepest pools at locations that were near DWR’s water quality and/or water temperature recorder locations in the lower Feather River (pers. comm., S. McReynolds 2003). In cases where no distinct deep pools were located near water quality and/or water temperature recorders, habitat types were sampled that had similar characteristics to deep pools (pers. comm., S. McReynolds 2003).

4.2.2.2 Final Report

Analyses of dissolved oxygen concentrations were not performed for the Final Report, because at no time during 2002 sampling efforts did dissolved oxygen concentration fall below 6.5 mg/L, which was the criterion reported by the EPA (2002) to be protective of all life salmonid stages other than embryonic, larval, or juvenile organisms. Because dissolved oxygen concentrations within pools were above 6.5 mg/L during all sampling efforts in 2002, and because water temperature data collected in 2002 and 2003 indicated that thermal stratification does not occur in the lower Feather River, it was assumed that dissolved oxygen concentrations in pools in 2003 would remain above 6.5 mg/L.

4.2.3 Analysis of Data Collected in Feather River Pools

4.2.3.1 Interim Report

Analysis of the water temperature and dissolved oxygen concentration data was performed by comparing collected data to existing information on suitable habitat for holding spring-run Chinook salmon. After comparison of existing information and the observed data, conclusions could be reached regarding the location and extent of suitable spring-run Chinook salmon holding habitat in the lower Feather River.

To analyze the water temperature data collected for the sixteen sampled pools, each sample date and location was individually assessed. At no time was data from an individual sampling date or combination of sampling dates within one month considered representative of that month. Therefore, data from individual sample dates should not be used to infer monthly water temperature trends. Each pool sampled also was considered individually. No inference was, or should be, made that any individual pool water temperature is representative of a reach, habitat type, or other pool upstream or downstream from the sampled pool.

To analyze individual pool suitability for holding adult spring-run Chinook salmon, the mean water column temperature was calculated and analyzed compared to the index water temperatures of 15°C (59°F) and 17°C (62.6°F). These indices were used because they are the endpoint water temperatures in the range at which sublethal effects are reported to begin to occur in Chinook salmon chronically exposed to that water temperature range. If mean water temperatures in a given pool for a given date were below 15°C (59°F), then it was considered, for that sample date in that individual pool, that water temperatures were suitable for holding adult Chinook salmon. If mean water temperatures in a given pool for a given date were above 17°C (62.6°C), then it was considered, for that sample date in that pool, that water temperatures were unsuitable for holding adult Chinook salmon. For pools with mean water temperatures between 15°C (59°F) and 17°C (62.6°F) it is unclear whether that pool on that sampling date provided suitable habitat holding adult Chinook salmon.

In addition to analysis of water temperature, water depth and dissolved oxygen data collected by DWR were compared to published data in order to identify and characterize potential holding habitat for spring-run Chinook salmon. The published EPA thirty-day mean dissolved oxygen concentration of 6.5 mg/L was used as the threshold for the dissolved oxygen concentration analysis, while a depth of 2 meters was used as the threshold for suitable holding pool depth.

Little data exist describing the size of preferred holding pools for adult spring-run Chinook salmon. Neither DFG (1998), or DWR and USBR (2000) mention pool size as an important criterion in determining holding pool habitat suitability. Therefore, pool size was not considered in the analysis.

4.2.3.2 Final Report

To analyze the water temperature column profile data collected from the sampled pools during the 2003 spring-run Chinook salmon immigration and holding period, each sample date and location was individually assessed using a similar methodology to that employed during analysis of the 2002 data for the Interim Report. At no time was data from an individual sampling date or combination of sampling dates within one month considered representative of that month. Therefore, water temperatures colleted on individual sample dates should not be used to infer monthly water temperature trends. Each pool sampled also was considered individually. No inference was, or should be, made that any individual pool water temperature is representative of a reach, habitat type, or nearby pool upstream or downstream from the sampled pool. To analyze individual pool profile data, the mean water column temperature was calculated and compared to the water temperature index values described in Section 4.1.9.3 to determine the number of average water column temperatures exceeding each of the water temperature index values. Daily maximum, mean, and minimum water temperatures were recorded by thermographs in 24 pools in the lower Feather River. However, daily maximum and minimum water temperatures represent a single data point that does not include the variation exhibited in a diel cycle. Reportedly, the effects from thermal stress are positively correlated with exposure times (EPA 2003; McCullough 1999). Therefore, daily mean thermograph data may be the most appropriate variable with which to gauge potential effects from thermal stress. Thus, analysis of water temperatures obtained from thermographs was performed by calculating the percentage of time that daily mean water temperatures exceeded each water temperature index value. However, in order to have comparable analyses, it was deemed necessary to consider equivalent time intervals for all time series data, which varied in length due to data losses. The selected time interval analyzed was July 4 to October 31, 2003 for overall comparative purposes among pools. In order to maintain consistency, only thermograph mean data with 96 data points recorded per day were considered in the analysis.

5.0 STUDY RESULTS

5.1 INTERIM REPORT

5.1.1 Analysis of Data Collected in Feather River Pools

5.1.1.1 Water Temperature

Analysis of water temperature data in potential spring-run Chinook salmon holding habitat was performed using index water temperatures based on endpoints of ranges reported by Marine (1992) that had various effects on chronically exposed adult Chinook salmon. The upper incipient lethal water temperature reported by Marine (1992) fell between 17°C (62.6°F) and 20°C (68°F). The water temperature range in which Marine (1992) reported sublethal effects occurring was between 15°C (59°F) and 17°C (62.6°F). The water temperature range reported for optimal pre-spawning broodstock survival, maturation, and spawning was between 6°C (42.8°F) and 14°C (57.2°F) (Marine 1992). Because no effects were reported for chronic exposure to water temperatures between 14°C (57.2°F) and 15°C (59°F), and because sublethal effects reportedly begin at 15°C (59°F), it was assumed that between 14°C (57.2°F) and 15°C (59°F) that no effects on holding adult Chinook salmon would occur. Below 6°C (42.8°F), Marine (1992) reported that increased mortality, retarded gonadal development and maturation, and infertility occurred in chronically exposed adult Chinook salmon (Marine 1992). Therefore, mean pool water column temperatures that fell below 6°C (42.8°F) were considered unsuitable for holding adult spring-run Chinook salmon in the Feather River. Analysis of available data showed that no sampled pools had mean water temperatures below 6°C (42.8°F). Because data were lost and because sampling only began in April (holding is assumed to begin in March), it was not possible to report that mean pool water temperatures did not fall below 6°C (42.8°F) at any time during the Chinook salmon immigration and holding period in pools with other suitable habitat characteristics. Although not used in this analysis, data did exist for most pools in December and all pools in January. Because mean water temperatures did not fall below 8.6°C (47.5°F) on any sample date, it was assumed that mean water temperatures had not fallen below 6°C (42.8°F) in any potentially suitable holding pools during the Chinook salmon immigration and holding period.

Most pools sampled showed mean water temperatures within the range reported by Marine (1992) as optimal for pre-spawning broodstock survival and maturation on some sample dates during the Chinook salmon immigration and holding period. Most pools had mean water column temperatures that fell between 15°C (59°F) and 17°C (62.6°F) on some sampling dates within the Chinook salmon immigration and holding period, and mean water column temperatures that fell above 17°C (62.6°F) on some sampling dates within the Chinook salmon immigration and holding period. Table 5.1-1 shows all available mean water temperatures for all sampled pools within the Chinook salmon immigration and holding period. Appendix D shows all raw water temperature data collected by DWR from April 2002 through October 2002, while Appendix E contains graphs showing the dates for which each pool mean water column temperature was above 17°C (62.6°F), between 15°C (59°F) and 17°C (62.6°F), and below 15°C (59°F).

Reach 1

Between the Fish Barrier Dam and Mathews Riffle, mean water column temperatures were within the reported optimal range for most of the sampling dates for which data were available (Table 5.1-1). Pools 1-1, 1-2, and 1-3 had mean water column temperatures between 6°C (42.8°F) and 14°C (57.2°F) on 12 out of 13 sampling dates within the Chinook salmon immigration and holding period. Mean water column temperatures for the sample date August 22, 2002 fell between 15°C (59°F) and 17°C (62.6°F). Data for the sample date August 7, 2002 were lost while no data were collected prior to April 30, 2002. In Pool 1-4, data only existed from August 22, 2002 through the end of the Chinook salmon immigration and holding period and represented six sampling dates. On all but one of those dates, mean water temperatures were in the 6°C (42.8°F) to 15°C (59°F) range. The mean water column temperature on August 22, 2002 was above 17°C (62.6°F). Within this reach, suitable water temperatures existed on most sampling dates, but on one date (August 22, 2002) in the three most upstream pools, mean water column temperatures were within the range reportedly likely to produce sublethal effects on holding salmon. In the most downstream pool within this reach (Pool 1-4) mean water column temperature on August 22, 2002 fell within the reported incipient lethal water temperature range (Table 5.1-1).

Reach 2

Between Mathews Riffle and the Thermalito Afterbay Outlet, both of the sampled pools had data available for six dates beginning on August 22, 2002 and continuing through October 24, 2002. Data collected prior to August 22, 2002 were lost. Pool 2-1 had mean water column temperatures within the reported optimal range on three of the six dates, between 15°C (59°F) and 17°C (62.6°F) on two dates, and above 17°C (62.6°F) on August 22, 2002. Pool 2-2 had mean water column temperatures within the reported optimal range on two of the six dates, between 15°C (59°F) and 17°C (62.6°F) on two dates, and above 17°C (62.6°F) on two dates. Within this reach, suitable holding habitat existed on some dates during the spring-run Chinook salmon immigration and holding period, but on some dates during the warmest summer month for which data were available (August) pool mean water column temperatures were within the reported potentially sublethal and incipient lethal ranges for chronically exposed Chinook salmon (Table 5.1-1).

Table 5.1-1. Mean water column temperature for each pool, for each sampling date, within the adult spring-run Chinook salmon immigration and holding period, 2002.

	04/30/02	05/16/02	05/30/02	06/12/02	06/27/02	07/15/02	07/25/02	08/07/02	08/22/02	08/26/02	09/05/02	09/26-27/02	10/8-9/02	10/24-25/02
Feather River downstream from Fish Barrier Dam Pool (Pool 1-1)	10.4	10.7	13.4	11.9	13.6	12.4	12.4		16.3	13.7	12.3	11.7	12.9	13.4
Feather River upstream from Hatchery Pool (Pool 1-2)	10.7	10.8	13.3	12.2	13.7	12.5	14.0		16.2	13.8	12.2	11.6	12.9	13.4
Feather River downstream from Hatchery Pool (Pool 1-3)	11.4	11.4	13.4	12.7	14.4	13.1	14.3		16.9	14.0	12.5	11.6	13.6	13.3
Feather R upstream from HWY 162 Bridge Pool (Pool 1-4)									18.0	14.9	14.0	11.6	14.7	13.3
Feather R US from Afterbay Outlet Pool (Pool 2-1)									18.4	16.2	14.8	13.3	15.0	13.8
Feather River at Afterbay Outlet Pool (Pool 2-2)									17.8	17.7	15.8	14.6	15.9	14.6
Feather R downstream from Afterbay Outlet Pool (Pool 3-1)									17.3	18.0	16.7	15.7	15.9	14.6
Feather R near Mile Long Pond Pool (Pool 3-2)									17.6	18.7	17.2	16.2	16.6	14.8
Feather R DS from Project Boundary Pool (Pool 3-3)									17.8	18.7	17.4	16.8	16.7	15.0
Feather R NR Gridley Pool (Pool 3-4)									17.7	19.0	17.1	16.7	16.5	14.8
Feather River Upstream from Honcut Creek(Pool 3-5)									17.7	19.2	16.8	16.6	16.3	14.7
Feather River at Archer Ave. Pool (Pool 4-1)									17.9	19.5	16.8	16.7	16.6	15.0
Feather River upstream from Yuba R. Pool (Pool 4-2)								20.0	18.6	20.1	17.2	17.9	17.0	14.9
Feather River at Shanghai Bend Pool (Pool 4-3)								18.7	18.5	19.4	17.4	18.0	17.0	14.8
Feather R A Star Bend Pool (Pool 4-4)								19.1	18.9	19.7	17.7	17.9	17.2	15.1
Feather R NR Verona Pool (Pool 4-5)								19.2	18.9	19.7	18.5	18.8	17.8	14.8

Water temperature (˚C)	Color code
6.0 - 14.9	Green
15.0 - 16.9	Yellow
≥ 17.0	Red
No data	Gray

Reach 3

Between the Thermalito Afterbay Outlet and Honcut Creek, data existed for all five pools sampled from August 22, 2002 through October 24, 2002, representing six sample dates. On only one date (October 24, 2002) did water temperatures in four pools (Pools 3-1, 3-2, 3-4, 3-5) fall within the reported optimal range for holding. Mean water column temperatures within the fifth pool (Pool 3-3) were never within the reported optimal range on any sample dates for which data were available within the spring-run Chinook salmon immigration and holding period during 2002. On August 22, and 26, 2002 all of the pools had mean water column temperatures above 17°C (62.6°F). On September 5, 2002, Pools 3-1 and 3-5 had mean water column temperatures between 15°C (59°F) and 17°C (62.6°F), while Pools 3-2, 3-3, and 3-4 had mean water column temperatures above 17°C (62.6°F). Within this reach, suitable water temperatures for holding occurred in some pools on October 24, 2002, near the end of the spring-run Chinook salmon immigration and holding period. All of the pools within the reach exhibited mean water temperatures within the reported sublethal and incipient lethal ranges on most sampled dates for which data were available (Table 5.1-1).

Reach 4

Between the confluence of the Feather River and Honcut Creek, and the confluence of the Sacramento and Feather rivers, data existed for seven dates between August 7, 2002 and October 24, 2002. An exception is that data for the most upstream pool in the reach (Pool 4-1) were lost for the August 7 sampling date. Mean water column temperatures in only three pools (Pool 4-2, 4-3, and 4-5) were within the reported optimal range for holding salmon on the last sampled date within the Chinook salmon immigration and holding period (October 24). The remaining two pools had mean water column temperatures between 15°C (59°F) and 17°C (62.6°F) on that date. Only one pool, Pool 4-1, had mean water column temperatures between 15°C (59°F) and 17°C (62.6°F) on four sampling dates (September 9 and 26, and October 8 and 24). For all dates and all pools within this reach, mean water column temperatures were above 17°C (62.6°F) except for the specific instances reported above. Therefore, within Reach 4 (Honcut Creek to the Sacramento River), suitable water column temperatures were recorded only in three pools on the last sampling date within the spring-run Chinook salmon immigration and holding period. Sublethal mean water column temperatures were recorded on four dates within the most upstream pool, while the remainder of the dates sampled had mean water temperatures within each pool that were within the reported upper incipient lethal range reported for chronically exposed salmon (> 17°C (62.6°F)). Table 5.1-1 shows mean water column temperatures in sampled pools in the Feather River reach that extends from the confluence of Honcut Creek and the Feather River to the confluence of the Sacramento and Feather rivers.

5.1.1.2 Index Value Exceedance in 2002

In order to facilitate comparison between data collected during the 2002 and 2003 spring-run Chinook salmon immigration and holding periods, mean water column temperatures observed in 2002 were analyzed with respect to the water temperature index values of 15.6°C (60°F), 17.8°C (64°F), and 20.0°C (68°F). Prior to August 7, 2002 water temperature data were available only for Pools 1-1, 1-2, and 1-3, during which time, no mean water column temperatures exceeded 15.6°C (60°F) on any sampling date. On August 7, 2002 water temperature data were available for Pools 4-2, 4-3, 4-3, and 4-4, during which time, the mean water column temperatures in the three most downstream pools exceeded 17.8°C (64°F) and the mean water column temperature in Pool 4-4 exceeded 20.0°C (68°F). From August 22 through October 25, 2002, water temperature data exist for all 16 pools sampled. For purposes of this analysis, observed mean water column temperatures that were equivalent to an index value were grouped with those water temperatures above the index value. For example, on August 22, 2002, Pool 3-3 had a mean water column temperature of 17.8°C (64°F). Therefore, Pool 3-3 was considered to have exceeded 17.8°C (64°F) on August 22, 2002.

From August 22 through October 25 Pools 1-1, 1-2, and 1-3 had mean water column temperatures that exceeded 15.6°C (60°F) once on August 22. Mean water column temperatures in Pool 1-4 exceeded 20.0°C (68°F) once on August 22. On the remainder of sampling dates during the 2002 spring-run Chinook salmon immigration and holding period, mean water column temperatures in Reach 1 remained below 15.6°C (60°F) (see Table 5.1-1).

Mean water column temperatures in Reach 2 exceeded 15.6°C (60°F) on one out of six sampling dates in Pool 2-1 and on three out of six sampling dates in Pool 2-1. Mean water column temperatures exceeded 17.8°C (64°F) on one out of six dates in both pools within the reach. No mean water column temperatures in either pool within the reach exceeded 20.0°C (68°F) on any sampling date for which data were available.

Mean water column temperatures in Reach 3 (Pools 3-1 through 3-5) exceeded 15.6°C (60°F) during 19 out of 30 (five pools and six sampling dates) sampling events. Mean water column temperatures exceeded 17.8°C (64°F) during six out of 30 sampling events. No mean water column temperatures in any pool within Reach 3 exceeded 20.0°C (68°F) on any sampling date for which data were available.

Mean water column temperatures were available for 34 sampling events (five pools and six sampling dates plus four pools on one sampling date) in Reach 4. Mean water column temperatures exceeded 15.6°C (60°F) during 15 out of 34 sampling events and exceeded 17.8°C (64°F) during 18 out of 34 sampling events. Mean water temperatures exceeded 20.0°C (68°F) during two out of 34 sampling events.

5.1.1.3 Thermal Migration Barriers in 2002

Although not originally analyzed in the Interim Report, the potential exists for thermal migration barriers to develop in each pool. Transient thermal barriers likely would not adversely affect holding adult spring-run Chinook salmon, but could potentially affect Chinook salmon production. If immigrating adult Chinook salmon encountered thermal barriers, especially above the confluence of a cooler tributary such as the Yuba River, the potential exists for individuals to discontinue migration up the Feather River and return downstream to select alternate migration corridors. For example, if immigrating adults encountered a thermal barrier upstream from the Yuba River, they could potentially return downstream and elect to enter the Yuba River, which would result in lost Feather River production.

Because McCullough (1999) and ODEQ (1995) report that migration barriers could potentially occur at 21°C (70°F), mean water column temperature data collected in 2002 in each pool were examined to determine the frequency of occurrence of water temperatures at or above 21°C (70°F). Although mean water column temperatures in some pools in Pool 4-2 did rise above 20°C (68°F) on two sampling dates during August 2002, no pool mean water column temperatures were observed above 21°C (70°F) on any sample dates in any pools during the 2002 spring-run Chinook salmon immigration and holding period.

5.1.1.4 August Water Temperatures

Sample dates in August yielded the warmest water temperatures for all sample locations and all sample dates for which data were available. Figure 5.1-1 shows the average mean water column temperatures for all available data for the month of August for each sampled pool. The values were calculated by averaging mean water column temperatures from each pool for each sample date in August. For example, the mean water column temperatures presented in Table 5.1-1 for Pool 4-5 (the most downstream pool sampled) for August 7, 22, and 26°C (78.8°F) were 19.2°C (66.6°F), 18.9°C (66°F), and 19.7°C (67.5°F), respectively. The mean, 19.3°C (66.7°F), of these three water temperatures is presented in Figure 5.1-1. The error bars shown on the figure indicate the minimum and maximum mean water column temperatures reported for any of those sample dates.

5.1.1.5 Water Temperature and Flow Fluctuations

Potentially significant differences in water temperatures between sampling dates in August occur throughout the study area. In the two reaches above the Thermalito Afterbay Outlet, mean water column temperatures in sampled pools decreased an average of approximately 2.2°C (4°F) between August 22 and August 26, 2002 while the two reaches below the Thermalito Afterbay Outlet showed an average increase of approximately 1.1°C (2°F) in mean water column temperature for the same dates. The water temperature changes could be attributed to increases in flow releases from Thermalito Diversion Dam and the Thermalito Afterbay Outlet. Calibration of the Instream Flow Incremental Methodology (IFIM) model developed for other tasks associated with the FERC relicensing process required increased flows in the river on August 26, 2002. Because water drawn from the hypolimnion Lake Oroville and released into the reach above the Thermalito Afterbay Outlet was cold, water temperatures in that reach decreased with higher flows. The opposite effect is evident below the Thermalito Afterbay Outlet because, in the summer months, water entering the Feather River from the Thermalito Afterbay is warmer than the river itself. In order to fully identify and characterize suitable holding habitat within the Feather River, a larger data set is required.

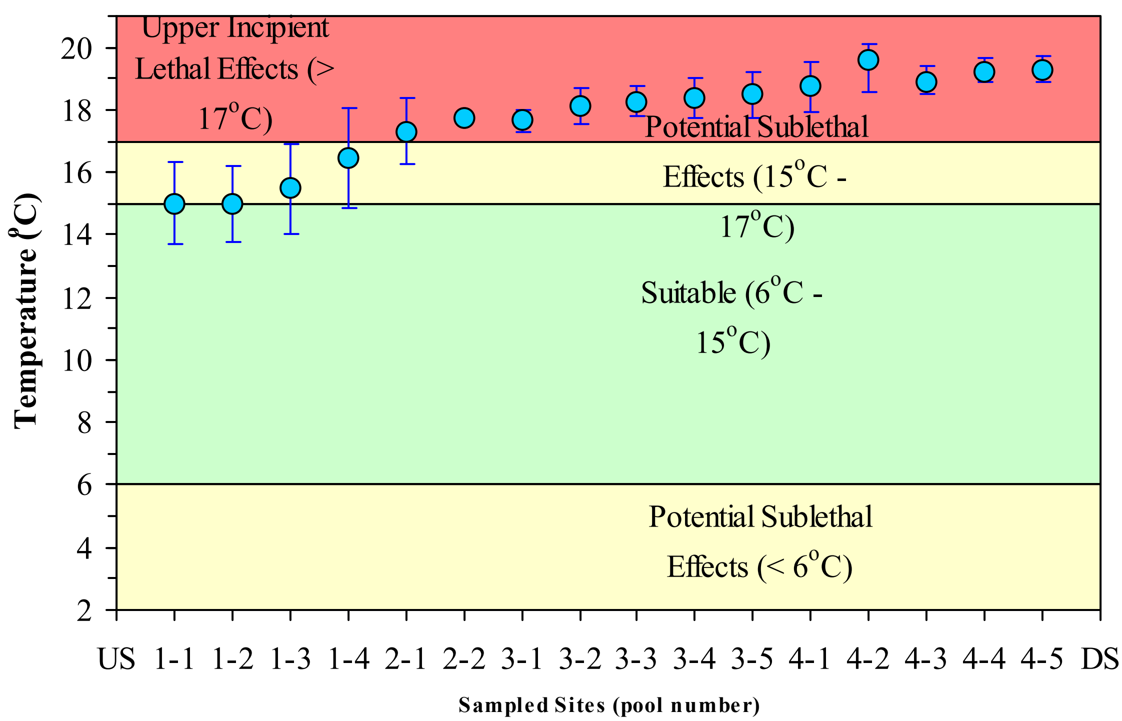

Figure 5.1-1. Average mean water column temperatures for August sampling dates in 2002 for each Feather River sample site, from upstream (US) to downstream (DS).
Note: Error bars indicate the minimum and maximum mean water column temperatures.

5.1.1.6 Dissolved Oxygen

Based on the dissolved oxygen concentrations reported by EPA (2002) to be sufficient to support coldwater aquatic species, all pools sampled on all dates can be considered suitable habitat for holding adult spring-run Chinook salmon. The thirty-day mean dissolved oxygen value reported to be suitable for all life stages other than embryonic, larval, or juvenile organisms is reported to be 6.5 mg/L. The thirty-day mean value was used for analysis purposes because it is the most protective (i.e. lowest dissolved oxygen concentration) value provided for post-juvenile life stages. At no time during sampling was dissolved oxygen less than 6.5 mg/L. In fact, the lowest dissolved oxygen concentration reported during the spring-run Chinook salmon immigration and holding period was 8.5 mg/L, recorded on August 26, 2002 at the Shanghai Bend Pool (Pool 4-3). Appendix D shows the raw data collected by DWR for all pools sampled in 2002.

5.1.1.7 Dissolved Oxygen and Flow Fluctuations

In addition to differences between mean water column temperatures observed between sampling dates in August 2002, changes in dissolved oxygen concentration also were observed. In general, dissolved oxygen concentrations increased at sample locations in Reaches 1 and 2 (upstream of the Thermalito Afterbay Outlet) and decreased at sample locations in Reaches 3 and 4 between August 22 and August 26 2002. These changes presumably are due to the increased flow releases during calibration of the IFIM model on August 26. Because dissolved oxygen concentrations were not at or near the EPA minimum standard at any locations during the spring-run Chinook salmon immigration and holding period, it is not anticipated that changes in flows similar to those during the IFIM calibration would decrease habitat suitability based on dissolved oxygen concentration.

5.1.1.8 Diel Water Temperature and Dissolved Oxygen Fluctuations

Evidence from the Middle Fork Eel River shows that, under certain flow conditions, potentially significant changes in water temperature can occur in a single pool during a single day (Nielsen et al. 1994). In fact, Nielsen et al. (1994) suggest that surface water temperature increased consistently by 3.5°C (6.3°F) during the day under low flow conditions. It is unclear whether this pattern would be evident under flow conditions exhibited in the Feather River. A cursory examination of available data in Pool 1-1 (the most upstream pool sampled, Table 5.1-1) shows that between sample date July 25, 2002 and August 22, 2002 mean water column temperatures increased from 12.4°C (54.3°F) to 16.3°C (61.3°F). A difference in sampling time from 0755 on July 25 to 1555 on August 22 is one factor among several that could cause a 3.9°C (7°F) increase in mean water column temperature between sample dates. However, samples taken in the same pool (Pool 1-1) at similar times on August 22 and September 5 show a mean water temperature difference of 4°C (7.2°F), which indicates that the time of year during which a sample was taken, and thus ambient air temperature, has a stronger influence on water temperature than the time of day, but does not provide evidence that sampling time does not affect mean water column temperature.

Evidence exists to suggest that dissolved oxygen concentration exhibits the opposite reaction to the diel cycle than water temperature. It has been reported in some systems that heavy plant growth during the summer months can lead to oxygen super saturation during the day due to photosynthesis (Giller and Malmqvist 2002). Because no dissolved oxygen concentrations are at or near the EPA minimum standard for coldwater species during the Chinook salmon immigration and holding period, it is not expected that dissolved oxygen concentration is a limiting factor in holding habitat availability in the Feather River. Without dissolved oxygen concentration measurements in individual pools at multiple times during any given day, it is not possible to rule out a drop in dissolved oxygen concentration below the minimum criterion provided by EPA (2002) at times during the spring-run Chinook salmon immigration and holding period.

5.1.1.9 Water Depth, Substrate, Cover, and Water Velocity

Based on available information on adult spring-run Chinook salmon holding habitat with respect to water depth, all pools sampled provided suitable habitat at all dates sampled within the spring-run Chinook salmon immigration and holding period, with some exceptions. Pools 1-3, 3-2, 4-2, and 4-5 were 1.5 meters deep on some of the sampling dates. Because pool depth is related to flow, the depth of these pools was suitable for some dates during the Chinook salmon immigration and holding period. Other parameters that could potentially determine the presence, location, and distribution of suitable holding habitat include substrate, cover, and velocity. None of these parameters were analyzed because no data were collected from the sampled pools during the spring-run Chinook salmon immigration and holding period.

<u>Depth Inconsistencies</u>

In some pools below the Thermalito Afterbay Outlet, inconsistencies appear with respect to the water depths of pools sampled. On August 26, 2002 flows were higher than on other sampling dates due to an effort to calibrate the IFIM model. Above the Thermalito Afterbay Outlet, the depth in all pools remained the same or increased. Some pools below the Thermalito Afterbay Outlet, however, showed decreases in depth during the IFIM Calibration on August 26. Pools 3-1 and 4-2 decreased in depth by approximately half a meter each during the IFIM calibration. Pools 4-1 and 4-4 each got shallower by a full meter during the increased flows on August 26. Additionally, all four of the other pools within Reach 3 remained at the same depth. Pool 4-3 increased in depth by a half meter and Pool 4-5 remained at the same depth. It is possible that water depth was not measured at the exact same locations as previous measurements within each pool, but it is unknown for certain why inconsistencies appear in the data.

5.2 FINAL REPORT

Two data sets were available from the sampling efforts conducted during the 2003 spring-run Chinook salmon immigration and holding period, pool profile water temperature data, which was collected in the same pools as the data collected ruing the 2002 spring-run Chinook salmon immigration and holding period, and thermograph data, which included many new sampling locations. Each data set was analyzed separately, the results of which are presented below.

5.2.1 Analysis of Water Temperature Data Collected in Feather River Pools

5.2.1.1 Water Column Profile Temperature Data

Analysis of water temperature data collected during the spring-run Chinook salmon immigration and holding period during 2003 in potential spring-run Chinook salmon holding habitat was performed by calculating the proportion of time that mean water column temperatures exceeded each of the three selected water temperature index values. Because data were only available for one date in March 2003 in the Near Mile Long Pond Pool (Pool 3-2), this pool was excluded from the analysis. Analysis of available data shows that all 15 pools included in the analysis had mean water column temperatures above the water temperature index value of 15.6°C (60°F). Eleven out of 15 sampled pools had mean water column temperatures above the water temperature index value of 17.8°C (64°F), and 10 out of 15 pools had mean water column temperatures above the water temperature index value of 20.0°C (68°F) (Figure 5.2-1). Consequently, it was assumed that risks of adult mortality and increased incidence of disease, along with the potential for subsequent embryonic developmental abnormalities, did exist at some times during the spring-run Chinook salmon immigration and holding period in 2003 in the sampled pools in the lower Feather River, particularly within the pools influenced by the Thermalito Afterbay outflow.

Table 5.2-1 shows all available mean water column temperatures for all sampled pools within the Chinook salmon immigration and holding period in 2003. Appendix A and Appendix B show all water temperature data collected by DWR from March through October 2003, while Appendix C contains graphs showing the dates for which each pool was above the water temperature index values of 15.6°C (60°F), 17.8°C (64°F), and 20°C (68°F).

Reach 1

Between the Fish Barrier Dam and Mathews Riffle, mean water column temperatures in Pools 1-1 and 1-2 ranged from 10°C (50°F) to 15.9°C (60°F). The mean water column temperature on July 10, 2003 was 15.9°C (60°F) for Pool 1-1 and Pool 1-2. In Pool 1-3 and Pool 1-4, mean water column temperatures ranged from 9.7°C (49.5°F) to 17°C (62.6°F). In Pool 1-3, the mean water column temperature on June 16, June 30, and July 25, 2003 reached 15.6°C (60°F), and on July 10 and August 6, 2003 the mean water column temperature reached 16.7°C (62.1°F) and 15.9°C (60°F), respectively. In Pool 1-4, the mean water column temperature exceeded the water temperature index value of 15.6°C (60°F) five times, and ranged between 15.8°C (60.4°F) and 17°C (62.6°F) between June 16 and August 6, 2003. Figure 5.2-1 and Table 5.2-1 show that Pools 1-1 and 1-2 had mean water column temperatures exceeding the water temperature index value of 15.6°C (60°F) approximately 8.3 percent of the time (i.e., 1 out 12 sampling events), and Pools 1-3 and 1-4 exceeded the water temperature index value of 15.6°C (60°F) approximately 41.7 percent of the time (i.e., 5 out 12 sampling events) during the 2003 spring-run Chinook salmon immigration and holding period. Mean water column temperatures never exceeded the water temperature index values of 17.8°C (64°F) and 20°C (68°F) between the Fish Barrier Dam and Mathews Riffle at locations and on dates for which data were available. Table 5.2-1 shows mean water column temperatures in sampled pools in the Feather River between the Fish Barrier Dam and Mathews Riffle.

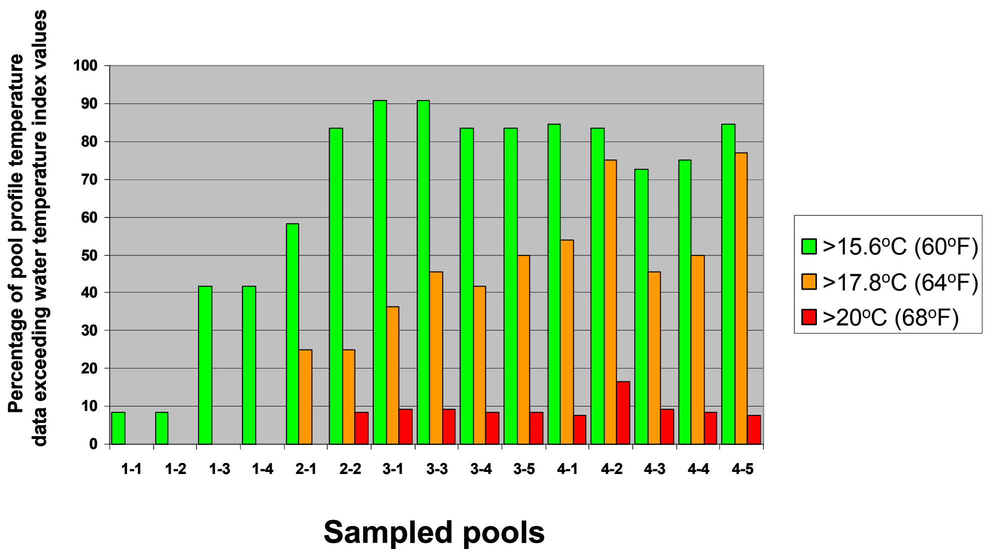

Figure 5.2-1. Percentage of time mean water column temperature exceeded each temperature index value in each sampled pool the 2003 spring-run Chinook salmon immigration and holding period.
Note: Bars represent percentage of water temperature data exceeding different water temperature index values, for that reason percentages become cumulative for lower water temperature index values.

Reach 2

Between Mathews Riffle and the Thermalito Afterbay Outlet (Reach 2), analysis of available water temperature data indicated that seven out of twelve times mean water column temperatures were above the water temperature index value of 15.6°C (60°F) in Pool 2-1. Mean water temperature exceeded the water temperature index value of 15.6°C (60°F) ten out of twelve sampled dates in Pool 2-2. In both Pools 2-1 and 2-2, on three out of twelve sampled dates, mean water column temperatures exceeded the water temperature index value of 17.8°C (64°F), and mean water column temperatures in Pool 2-2 exceeded the water temperature index value of 20.0°C (68°F) once on June 27,2003.

Table 5.2-1. Mean water column temperature for each pool for each sampling date within the adult spring-run Chinook salmon immigration and holding period (March to October) in the Feather River during 2002 and 2003.

Station Name	Sampling Event/Mean Water Column Temperature																Proportion of Sampling Events Above Index Value (and below subsequent index value)		
2002		**4/30**	**5/16**	**5/30**	**6/12**		**6/27**	**7/15**	**7/25**	**8/7**	**8/22**	**8/26**	**9/5**	**9/26 9/27**	**10/8 10/9**	**10/24 10/25**	**≥15.6°C (60°F)**	**≥17.8°C (64°F)**	**≥20°C (68°F)**
Feather R DS from Fish Barrier Dam Pool (Pool 1-1)		10.4	10.7	13.4	11.9		13.6	12.4	12.4		16.3	13.7	12.3	11.7	12.9	13.4	8%	0%	0%
Feather R US from Hatchery Pool (Pool 1-2)		10.7	10.8	13.3	12.2		13.7	12.5	14.0		16.2	13.8	12.2	11.6	12.9	13.4	8%	0%	0%
Feather R DS from Hatchery Pool (Pool 1-3)		11.4	11.4	13.4	12.7		14.4	13.1	14.3		16.9	14.0	12.5	11.6	13.6	13.3	8%	0%	0%
Feather R US from Highway 162 Pool (Pool 1-4)											18.0	14.9	14.0	11.6	14.7	13.3	0%	17%	0%
Feather R US from Afterbay Outlet Pool (Pool 2-1)											18.4	16.2	14.8	13.3	15.0	13.8	17%	17%	0%
Feather River at Afterbay Outlet (Pool 2-2)											17.8	17.7	15.8	14.6	15.9	14.6	50%	17%	0%
Feather R DS from Afterbay Outlet Pool (Pool 3-1)											17.3	18.0	16.7	15.7	15.9	14.6	67%	17%	0%
Feather R N Mile Long Pond (Pool 3-2)											17.6	18.7	17.2	16.2	16.6	14.8	67%	17%	0%
Feather R DS from Project Boundary Pool (Pool 3-3)											17.8	18.7	17.4	16.8	16.7	15.0	50%	33%	0%
Feather R Near Gridley Pool (Pool 3-4)											17.7	19.0	17.1	16.7	16.5	14.8	67%	17%	0%
Feather R US from Honcut C Pool (Pool 3-5)											17.7	19.2	16.8	16.6	16.3	14.7	67%	17%	0%
Feather River at Archer Ave. Pool (Pool 4-1)											17.9	19.5	16.8	16.7	16.6	15.0	50%	33%	0%
Feather River upstream from Yuba R. Pool (Pool 4-2)										20.0	18.6	20.1	17.2	17.9	17.0	14.9	29%	29%	29%
Feather River at Shanghai Bend Pool (Pool 4-3)										18.7	18.5	19.4	17.4	18.0	17.0	14.8	29%	57%	0%
Feather R A Star Bend Pool (Pool 4-4)										19.1	18.9	19.7	17.7	17.9	17.2	15.1	29%	57%	0%
Feather R NR Verona Pool (Pool 4-5)										19.2	18.9	19.7	18.5	18.8	17.8	14.8	0%	86%	0%
2003	**3/20 3/21**	**4/25**	**5/16**	**5/30**	**6/13**	**6/16**	**6/27 6/30**	**7/9 7/10**	**7/24 7/25**	**8/6 8/7**	**8/21 8/22**		**9/4 9/5**	**9/18 9/19**	**10/2**		**≥15.6°C (60°F)**	**≥17.8°C (64°F)**	**≥20°C (68°F)**
Feather R DS from Fish Barrier Dam Pool (Pool 1-1)*	10	10.2	11.5	13.2		14.7	15.1	15.9	14.9	15.4	13.6		11.7	11.6			8%	0%	0%
Feather R US from Hatchery Pool (Pool 1-2)*	10	10.3	11.7	13.2		14.8	15.1	15.9	15.1	15.5	13.6		11.8	11.6			8%	0%	0%
Feather R DS from Hatchery Pool (Pool 1-3)*	9.7	10.5	12.2	14.2		15.6	15.6	16.7	15.6	15.9	13.8		12.6	12.2			42%	0%	0%
Feather R US from Highway 162 Pool (Pool 1-4)*	9.8	10.9	13.2	15.2		16.8	15.8	17	16.2	15.8	13.9		13.3	13.1			42%	0%	0%
Feather R US from Afterbay Outlet Pool (Pool 2-1)*	11	11.3	14.6	16.2		18.1	18.8	18.4	17.6	17.4	15.5		16.2	14.3			25%	25%	0%
Feather River at Afterbay Outlet (Pool 2-2)	12.7	12.9	17	17.3		19	20.2	17.4	18	17.3	16		16.3	16.2			58%	17%	8%
Feather R DS from Afterbay Outlet Pool (Pool 3-1)*		12.9	18.5	17.9		18.9	21	17.2	17.7	17.7	15.7		16.9	16.1			54%	27%	9%
Feather R N Mile Long Pond (Pool 3-2)	14.7																0%	0%	0%
Feather R DS from Project Boundary Pool (Pool 3-3)*		13	18.8	17.5		19.6	21.4	17.1	17.9	18.1	16.1		17.1	16.3			46%	36%	9%
Feather R Near Gridley Pool (Pool 3-4)*	14.3	13.1	18.3	17.2		19.5	21.5	17.1	19.1	18.3	16.2		17.7	15.9			42%	33%	8%
Feather R US from Honcut C Pool (Pool 3-5)*	14.2	13.3	17.8	17.2		19.3	21.9	18.2	19.1	19	16.4		17.6	15.8			33%	42%	8%
Feather River at Archer Ave. Pool (Pool 4-1)	15.1	13.2	17.8	17.1	19.4	19.9	21.6	18.2	19	19	16.5		17.2	16.1			31%	46%	8%
Feather River upstream from Yuba R. Pool (Pool 4-2)	14.7	13.6	18.6	18.5	20.4		22.9	18.7	19.4	18.8	17.4		17.9	18.1			8%	58%	17%
Feather River at Shanghai Bend Pool (Pool 4-3)	12.5	12.7	14.8	16.1	17.5		21.1	18.4	18.7	17.8	17.1			18.2			27%	36%	9%
Feather R A Star Bend Pool (Pool 4-4)	12.8	12.7	14.8	15.7	17.2		21.2	18.6	19	18	17.1		18.2	18.2			25%	42%	8%
Feather R NR Verona Pool (Pool 4-5)	12.9	12.9	16.1	17.9	17.9		21.4	18.5	19.2	18.6	18		18.6	18.3	18.8		8%	69%	8%

Cell color indicates that water temperatures were equal to or higher than Water Temperature Index Values for the spring-run Chinook salmon immigration and holding life stage: Green (15.6°C, 60°F), Yellow (17.8°C, 64°F) and blue (20°C, 68°F). Grey colored cells indicate no data available. Thermograph data are also available for 9 pools marked with an asterisk starting in 2003.

In Pool 2-1, five out of twelve sampling dates had mean water column temperatures between 11°C (52°F) and 15.5°C (60°F). Mean water column temperatures exceeded the water temperature index values of 15.6°C (60°F) and 17.8°C (64°F), seven and three times, respectively. Additionally, mean water column temperatures ranged between 16.2°C (61.2°F) and 18.8°C (65.8°F) between May 30 and September 4, 2003. In Pool 2-2, two out of twelve sampling dates had mean water column temperatures between 12.7°C (54.8°F) and 12.9°C (55°F). Mean water column temperatures exceeded the water temperature index values of 15.6°C (60°F), 17.8°C (64°F), and 20.0°C (68°F), ten times, three times, and one time, respectively during the 2003 spring-run Chinook salmon immigration and holding period, and ranged between 16.0°C (60.8°F) and 20.2°C (68.4°F) between May 16 and September 19, 2003. Mean water column temperature exceeded the water temperature index value of 20.0°C (68°F) only one time at the Afterbay Outlet (Pool 2-2) on June 27, 2003, but remained below the reported potential thermal barrier of 21°C (69.8°F). Figure 5.2-1 shows that Pool 2-1 and Pool 2-2 had mean water temperatures exceeding the water temperature index value of 15.6°C (60°F) during 58.3 percent and 83.3 percent of the sampling dates, respectively. Pools 2-1 and 2-2 exceeded the water temperature index value of 17.8°C (64°F) during 25 percent of the sampling dates, and Pool 2-2 exceeded the water temperature index value of 20.0°C (68°F) during 8.3 percent of the sampling dates. Table 5.2-1 shows mean water temperatures in sampled pools in the Feather River reach that extends from Mathews Riffle to the Thermalito Afterbay Outlet.

Reach 3

Between the Thermalito Afterbay Outlet and Honcut Creek (Reach 3), data exists for four pools sampled from March 20, 2003 through September 19, 2003, representing twelve sampling dates. Data were available only for March 2003 in the Near Mile Long Pond Pool (Pool 3-2). Consequently data obtained from Pool 3-2 was excluded from this analysis. Mean water column temperatures in Pools 3-1 and 3-3 exceeded the water temperature index value of 15.6°C (60°F) on ten out of eleven sampled dates, and Pools 3-4 and 3-5 exceeded the water temperature index value of 15.6°C (60°F) on ten out of twelve sampled dates (Table 5.2-1). In Pools 3-1, 3-3, 3-4, and 3-5 mean water temperatures exceeded the water temperature index value of 20.0°C (68°F) in late June. In Pool 3-1, mean water column temperatures exceeded the water temperature index value of 17.8°C (64°F), four times out of eleven sampling dates. Mean water column temperatures ranged between 15.7°C (60.3°F) and 21°C (69.8°F) between May 16 and September 19, 2003. The maximum water column temperature of 21°C occurred on June 27, 2003. Pool 3-2 was sampled only on March 20, 2003 and had a mean water column temperature of 14.7°C (58.5°F). Pool 3-3 had mean water column temperatures exceeding the water temperature index value of 17.8°C (64°F) five times out of eleven sampling dates. Mean water column temperatures ranged between 16.1°C (70°F) and 21.4°C (70.5°F) between May 16 and September 19, 2003. The maximum water column temperature of 21.4°C occurred on June 27, 2003. In Pool 3-4, mean water column temperatures exceeded the water temperature index value of

17.8°C (64°F) five times out of twelve sampling dates. Mean water column temperatures ranged between 15.9°C (60.6°F) and 21.5°C (70.7°F) between May 16 and September 19, 2003. The maximum water column temperature of 21.5°C occurred on June 27, 2003 and is above the reported water temperature that could act as a thermal barrier. In Pool 3-5, mean water column temperatures exceeded the water temperature index value 17.8°C (64°F) six times out of twelve sampling dates. Mean water column temperatures ranged between 15.8°C (60.4°F) and 21.9°C (71.4°F) between May 16 and September 19, 2003. The maximum water column temperature of 21.9°C occurred on June 27, 2003. Figure 5.2-1 shows that Pools 3-1 and 3-3, and Pools 3-4 and 3-5, had mean water column temperatures exceeding the water temperature index value of 15.6°C (60°F), on 90.9 percent and 83.3 percent of the sampling dates, respectively. Pools 3-1, 3-3, 3-4, and 3-5 exceeded the water temperature index value of 17.8°C (64°F) on 36.4 percent, 45.5 percent, 41.7 percent, and 50 percent of the sampling dates, respectively. Pools 3-1 and 3-3 exceeded the water temperature index value of 20.0°C (68°F) on 9.1 percent of the sampling dates. Pools 3-4 and 3-5 exceeded the water temperature index value of 20.0°C (68°F) on 8.3 percent of the sampling dates within the Chinook salmon immigration and holding period. Table 5.2-1 shows mean water temperatures in sampled pools in the Feather River reach that extends from the Thermalito Afterbay Outlet and Honcut Creek.

Reach 4

Between the confluence of the Feather River and Honcut Creek, and the confluence of the Sacramento and Feather rivers (Reach 4), data exists for five pools sampled on twelve dates between March 20, 2003 and September 19, 2003. Additional data exist for Pools 4-1 and 4-5, which were sampled on thirteen dates on June 16 and October 2, 2003, respectively. In Pool 4-1, mean water column temperatures exceeded the water temperature index values of 15.6°C (60°F), 17.8°C (64°F), and 20.0°C (68°F) eleven times, seven times, and one time out of thirteen sampling dates, respectively (Table 5.2-1). Mean water column temperatures ranged between 16.1°C (61°F) and 21.6°C (70.9°F) between May 16 and September 19, 2003. The maximum water column temperature of 21.6°C occurred on June 27, 2003. In Pool 4-2, mean water column temperatures exceeded the water temperature index values of 15.6°C (60°F), 17.8°C (64°F), and 20.0°C (68°F) ten times, nine times, and two times out of twelve sampling dates, respectively. Mean water column temperatures ranged between 17.4°C (63.3°F) and 22.9°C (73.2°F) between May 16 and September 18, 2003. The maximum water column temperature of 22.9°C occurred on June 27, 2003. In Pool 4-3, mean water column temperatures exceeded the water temperature index values of 15.6°C (60°F), 17.8°C (64°F), and 20.0°C (68°F) eight times, five times, and one time out of eleven sampling dates, respectively. Mean water column temperature ranged between 16.1°C (61°F) and 21.1°C (70°F) between May 30 and September 18, 2003. The maximum water column temperature of 21.1°C occurred on June 27, 2003 and was above the water temperature at which thermal barriers to migration are reported to occur. In Pool 4-4, mean water column temperatures exceeded the water temperature index values of

15.6°C (60°F), 17.8°C (64°F), and 20.0°C (68°F) nine times, six times, and one time out of twelve sampling dates, respectively. Mean water column temperatures ranged between 15.7°C (60.3°F) and 21.2°C (70.2°F) between May 30 and September 18, 2003. The maximum water column temperature of 21.2°C occurred on June 27, 2003 and was above the water temperature at which thermal barriers to migration are reported to occur. In Pool 4-5, mean water column temperatures exceeded the water temperature index values of 15.6°C (60°F), 17.8°C (64°F), and 20.0°C (68°F) eleven times, ten times, and one time out of thirteen sampling dates, respectively. Mean water column temperatures ranged between 16.1°C (61°F) and 21.4°C (70.5°F) between May 16 and October 2, 2003. The maximum water temperature of 21.4°C occurred on June 27, 2003. Figure 5.2-1 shows that Pools 4-1, 4-2, 4-3, 4-4, and 4-5 had mean water column temperatures exceeding the water temperature index value of 15.6°C (60°F) on 84.6 percent, 83.3 percent, 72.7 percent, 75 percent, and 84.6 percent of the sampled dates, respectively. Pools 4-1, 4-2, 4-3, 4-4, and 4-5 had mean water column temperatures exceeding the water temperature index value of 17.8°C (64°F) by 53.8 percent, 75 percent, 45.5 percent, 50 percent, and 76.9 percent of the sampled dates, respectively. Pools 4-1, 4-2, 4-3, 4-4, and 4-5 had mean water column temperatures exceeding the water temperature index value of 20.0°C (68°F) by 7.7 percent, 16.7 percent, 9.1 percent, 8.3 percent, and 7.7 percent of the sampled dates, respectively. Table 5.2-1 shows mean water temperatures in sampled pools in the Feather River reach that extends from the confluence of Honcut Creek and the Feather River to the confluence of the Sacramento and Feather rivers.

June-July water temperatures

Sample dates in late June and July yielded the warmest water temperatures for all sample locations and all pool profile data. Figure 5.2-2 shows the average mean water column temperatures for all available data between June 27 and July 25, 2003 for each sampled pool. The values were calculated by averaging mean water column temperatures from each pool for each sample date between June 27 and July 25, 2003. For example, the mean water column temperatures presented in Table 4.2-1 for Pool 4-5 (the most downstream pool sampled) for June 27, July 9, and July 24, 2003 were 21.4°C (70.5°F), 18.5°C (65.3°F), and 19.2°C (66.5°F), respectively. The mean of these three water temperatures, 19.7°C (67.5°F), is presented in Figure 5.2-2.

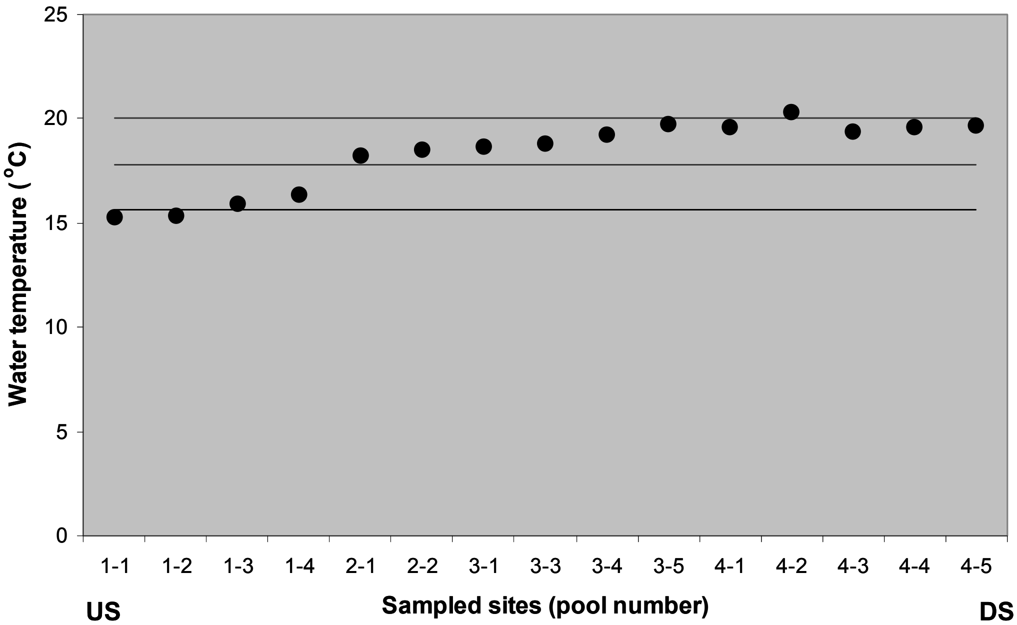

Figure 5.2-2. Mean water column temperatures for late June through July 2003 sample dates for each Feather River sample site, from upstream (US) to downstream (DS).
Note: Lines indicate the water temperature index values of 15.6°C (60 °F), 17.8°C (64 °F) and 20°C (68 °F) for the spring-run Chinook salmon immigration and holding life stage.

5.2.1.2 Thermograph Water Temperature Data

Daily thermograph time series data

Because thermographs were installed in several additional pools in 2003, the pool numeric nomenclature utilized for analysis of the 2002 and 2003 pool profile data was abandoned in favor of using only pool names for analysis of the thermograph data. Figures 4.1-1 and 4.1-2 show the locations of the pools in which thermographs were installed. Analysis of thermograph water temperature data was performed by reporting the percentages of mean daily water temperature data observed in each pool that exceeded the water temperature index values of 15.6°C (60°F), 17.8°C (64°F) and 20°C (68°F). Analysis of complete mean daily thermograph time series data (e.g., July 4 to October 31, 2004) shows all thirteen thermographs for which a complete time series exist, exceeded the water temperature index value of 15.6°C (60°F), and 10 out of 13 sampled pools had mean water temperatures above the index value of 17.8°C (64°F), respectively (Figure 5.2-3). Specific dates when water temperature index values were exceeded are described below.

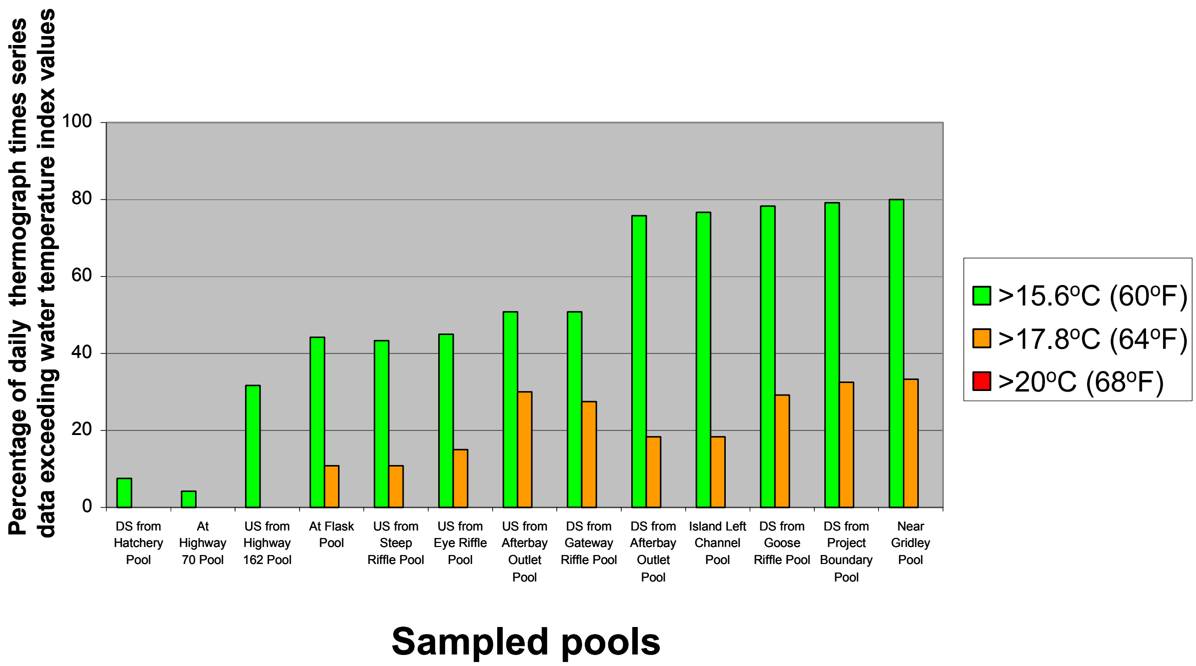

Figure 5.2-3. Percentage of time that mean daily water temperatures exceeded each water temperature index value in each sampled pool for which complete time series data were available from July 4 through October 31, 2003 during the 2003 spring-run Chinook salmon immigration and holding period.
Note: Bars represent percentage of water temperature data exceeding different water temperature index values, for that reason percentages become cumulative for lower water temperature index values.

Thermal regimes for each pool throughout the spring-run Chinook salmon immigration and holding period were represented by partial and full thermograph time series data. A full thermograph time series was characterized by having mean water temperature data every day from July 4 to October 31, 2003, and a partial thermograph series contained gaps in the time series data from July 4 to October 31, 2003. Because some thermograph data were unavailable comparative analysis of thermograph data exceeding water temperature index values was possible for 13 out of 24 pools. The other 11 out of 24 pools were analyzed only during the time intervals for which thermograph data existed. It should be noted that no conclusions were drawn, or inferences were made regarding mean pool water temperatures for those dates for which no data were available. No comparative analysis was possible for the 11 thermographs for which some data were unavailable, because dates for which water temperature data were available varied for each thermograph. Graphs of the mean daily water temperatures observed in each of the potential spring-run Chinook salmon holding pools during the time periods for which data were available in 2003 are presented in Appendix C.

The thermal regime of the pool named DS from Fish Barrier Dam Pool (Figure 4.1-1) was represented by thermograph data from June 20 to August 5, and from October 4 through October 31, 2003, during which time average daily water temperatures exceeded the water temperature index value of 15.6°C (60°F) approximately 2.7 percent of the time (i.e., 2 out of 75 sampled dates, on July 9 and 10). The water temperature index values of 17.8°C (64°F) and 20.0°C (68°F) were never exceeded in the pool named DS from Fish Barrier Dam Pool during the period for which thermograph data were available.

The thermal regime of the pool named US from Hatchery Pool (Figure 4.1-1) was represented by thermograph data available from June 20 through October 29, 2003, during which time, average water temperatures exceeded the water temperature index value of 15.6°C (60°F) approximately 4.5 percent of the time (i.e., 6 out of 132 sampled dates, on July 9,10, and 23; August 6, 7 and 12, 2003). The water temperature index values of 17.8°C (64°F) and 20.0°C (68°F) were never exceeded in the pool named US from Hatchery Pool during the period for which thermograph data were available.

The thermal regime of the pool named US from Auditorium Riffle Pool (Figure 4.1-1) was represented by thermograph data available from July 4 through July 19, and from August 20 to October 31, 2003, during which time, average water temperatures exceeded the water temperature index value of 15.6°C (60°F) approximately 2.2 percent of the time (i.e., 2 out of 91 sampled dates on July 9 and 10). The water temperature index values of 17.8°C (64°F) and 20.0°C (68°F) were never exceeded in the pool named US from Auditorium Riffle Pool during the period for which thermograph data were available.

The thermal regime of the pool named DS from Hatchery Pool (Figure 4.1-1) had average water temperatures exceeding the water temperature index value of 15.6°C (60°F) approximately 7.5 percent of the time (i.e., 9 out of 120 analyzed dates from July 4 through October 31, 2003), with exceedance occurring on July 9, 10, 15, 16, 22, and 23, and on August 6, 7, and 12. The water temperature index values of 17.8°C (64°F) and 20.0°C (68°F) were never exceeded in the pool named DS from Hatchery Pool during the period for which thermograph data were available.

The pool named At Highway 70 Pool (Figure 4.1-1) exceeded the water temperature index value of 15.6°C (60°F) approximately 4.2 percent of the time (i.e., 5 out of 120 analyzed dates from July 4 through October 31, 2003), all of which was in July. Exceedance occurred on July 10, 11, 15, 16, and 23. The water temperature index values of 17.8°C (64°F) and 20.0°C (68°F) were never exceeded in the pool named At Highway 70 Pool during the period for which thermograph data were available.

The pool named US from Highway 162 Pool (Figure 4.1-1) had average water temperatures exceeding the water temperature index value of 15.6°C (60°F) approximately 31.7 percent of the time (i.e., 38 out of 120 analyzed dates from July 4 to October 31, 2003), with exceedance occurring from July 4 through August 13, and from August 24 through August 27 (except July 18, 20 and 28 and August 1,2 and 9). No thermograph data from the pool named US from Highway 162 Pool ever exceeded the water temperature index values of 17.8°C (64°F) and 20.0°C (68°F).

The thermal regime of the pool named DS from Matthew's Riffle Pool (Figure 4.1-1) was represented by thermograph data available from September 10 through October 31, 2003. No water temperatures recorded in the pool named DS from Mathew's Riffle Pool ever exceeded the water temperature index values of 15.6°C (60°F), 17.8°C (64°F) and 20.0°C (68°F). It should be noted, however, that water temperature data were only available for the pool named Downstream From Matthew's Riffle Pool at the end of the spring-run Chinook salmon immigration and holding period when low water temperatures became prevalent.

The thermal regime of the pool named US from Great Western Pool (Figure 4.1-1) was represented by thermograph data available from June 27 through September 7, and from October 24 through October 31, 2003. Average water temperatures during those time periods exceeded the water temperature index value of 15.6°C (60°F) approximately 75.3 percent of the time (i.e., 61 out of 81 sampled dates), with exceedance occurring from June 27 through August 14, and from August 20 through August 31. Additionally, the water temperature index value of 17.8°C (64°F) was exceeded approximately 2.5 percent of the time (i.e., 2 out of 81 sampled dates on July 10 and 11). Mean daily water temperatures never exceeded the water temperature index value of 20.0°C (68°F) in the pool named US from Great Western Pool during the time period for which thermograph data were available.

The thermal regime of the pool named Granite Pool (Figure 4.1-1) was represented by thermograph data available from July 9 through August 23, and from October 28 through October 31, 2003. Average water temperatures exceeded the water temperature index value of 15.6°C (60°F) approximately 72 percent of the time (i.e., 36 out of 50 sampled dates), with exceedance occurring from July 9 through August 1, from August 3 through August 13, and on August 23. The water temperature index value of 17.8°C (64°F) was exceeded approximately 6 percent of the time representing 3 out of 50 sampled dates (i.e., July 10, 11, and 23, 2003). No mean daily water temperatures ever exceeded the water temperature index value of 20.0°C (68°F) during the period for which data were available.

The pool named At Flask Pool (Figure 4.1-1) had average water temperatures exceeding the water temperature index value of 15.6°C (60°F) approximately 44.2 percent of the time (i.e., 53 out of 120 analyzed dates from July 4 to October 31, 2003), with exceedance occurring from July 4 through August 14, from August 19 through August 21, and from August 23 through August 30 (Figure 5.2-3). Mean daily water temperatures exceeded the index value of 17.8°C (64°F) approximately 10.8 percent of the time (i.e., 13 out of the 120 analyzed dates from July 4 to October 31, 2003), with exceedance occurring from July 9 through 17, from July 22 through July 24, and on August 7. No mean daily water temperatures were observed above the water temperature index value of 20.0°C (68°F) during the period for which data were available.

Water temperatures in the pool named US from Steep Riffle Pool (Figure 4.1-1) exceeded the water temperature index value of 15.6°C (60°F) approximately 43.3 percent of the time (i.e., 52 out of 120 analyzed dates from July 4 to October 31, 2003), with exceedance occurring from July 4 through August 14, from August 19 through August 21, and from August 23 through August 29. Mean daily water temperatures exceeded the index value of 17.8°C (64°F) approximately 10.8 percent of the time (i.e., 13 out of the 120 analyzed dates from July 4 to October 31, 2003), with exceedance occurring from July 9 through July 17, from July 22 through July 24, and on August 7. No mean daily water temperatures were observed above the water temperature index value of 20.0°C (68°F) during the period for which water temperature data were available.

The thermal regime of the pool named DS from Steep Riffle Pool (Figure 4.1-1) was represented by thermograph data available from July 3 through August 28, and from September 7 through October 31, 2003. Average water temperatures exceeded the water temperature index value of 15.6°C (60°F) approximately 50.9 percent of the time (i.e., 57 out of 112 sampled dates), with exceedance occurring from July 3 through August 28. The water temperature index value of 17.8°C (64°F) was exceeded approximately 38.4 percent of the time (i.e., 43 out of 112 sampled dates), with exceedance occurring from July 3 through August 1, from August 4 through August 13, and from August 25 through August 28. No mean daily water temperatures were observed above the water temperature index value of 20.0°C (68°F) during the period for which water temperature data were available.

The pool named US from Eye Riffle Pool (Figure 4.1-1) had average water temperatures exceeding the water temperature index value of 15.6°C (60°F) approximately 45 percent of the time (i.e., 54 out of 120 analyzed dates from July 4 through October 31, 2003), with exceedance occurring from July 4 through August 14, and from August 19 through August 30. The water temperature index value of 17.8°C (64°F) was exceeded approximately 15 percent of the time (i.e., 18 out of 120 analyzed dates from July 4 through October 31, 2003), with exceedance occurring from July 5 through July 17, from July 22 through 24, on July 30, and on August 7. No mean daily water temperatures were observed above the water temperature index value of 20.0°C (68°F) during the period for which mean daily water temperatures were available.

The pools named US from Afterbay Outlet Pool and DS from Gateway Riffle Pool (Figure 4.1-1) both had average water temperatures exceeding the water temperature index value of 15.6°C (60°F) approximately 50.8 percent of the time (i.e., 61 out of the 120 analyzed dates from July 4 to October 31, 2003, with exceedance occurring from July 4 through September 4 (except for September 1 and 3)). The pool named US from Afterbay Outlet Pool had average water temperatures exceeding the water temperature index value of 17.8°C (64°F) approximately 30 percent of the time (i.e., 36 out of the 120 analyzed dates from July 4 to October 31, 2003) with exceedance occurring from July 4 through August 1, from August 6 through August 8, on August 13, and from August 25 through August 27. The pool named DS from Gateway Riffle Pool (Figure 4.1-1) had average water temperatures exceeding the water temperature index value of 17.8°C (64°F) approximately 27.5 percent of the time (i.e., 33 out of the 120 analyzed dates from July 4 to October 31, 2003), with exceedance occurring from July 4 through July 31, from August 6 through August 8, and from August 26 through August 27. Mean daily water temperatures in both pools never exceeded the water temperature index value of 20.0°C (68°F) during the period for which water temperature data were available.

The pool named DS from Afterbay Outlet Pool (Figure 4.1-1) had average water temperatures exceeding the water temperature index value of 15.6°C (60°F) approximately 75.8 percent of the time (i.e., 91 out of the 120 analyzed dates from July 4 to October 31, 2003), with exceedance occurring from July 4 to September 7, on September 14, and from September 16 to October 9. Average water temperatures exceeded the water temperature index value of 17.8°C (64°F) approximately 18.3 percent of the time (i.e., 22 out of the 120 analyzed dates from July 4 to October 31, 2003), with exceedance occurring from on July 11, 12, 16, 17, 18, and 20, from July 24 through July 28, on August 1, and from August 7 through August 16. Average water temperatures did not exceed the water temperature index value of 20.0°C (68°F) during the period for which water temperature data were available.

Mean thermograph data recorded in the pool named Island Left Channel Pool (Figure 4.1-1) exceeded the water temperature index value of 15.6°C (60°F) approximately 76.7 percent of the time (i.e., 92 out of the 120 analyzed dates from July 4 to October 31, 2003), with exceedance occurring from July 4 through September 7, and from September 14 through October 9. Average water temperatures exceeded the water temperature index value of 17.8°C (64°F) approximately 18.3 percent of the time (i.e., 22 out of the 120 analyzed dates from July 4 to October 31, 2003), with exceedance occurring on July 11, 12, 16, 17, 18, 20, from July 24 through July 28, on August 1, and from August 7 through August 16. Average water temperatures did not exceed the water temperature index value of 20.0°C (68°F) during the period for which water temperature data were available.

The thermal regime of the pool named US from Keester Riffle Pool (Figure 4.1-1) was represented by thermograph data available from July 4 through August 5, and from September 25 through October 31, 2003. Average water temperatures exceeded the water temperature index value of 15.6°C (60°F) approximately 68.6 percent of the time (i.e., 48 out of 70 sampled dates), with exceedance occurring from July 4 through August 5, and from September 25 through October 9, 2003. The water temperature index value of 17.8°C (64°F) was exceeded approximately 24.3 percent of the time (i.e., 17 out of 70 sampled dates), with exceedance occurring on July 11 and 12, from July 16 through July 21, from July 23 through July 29, on July 31, and on August 1. Average water temperatures did not exceed the water temperature index value of 20.0°C (68°F) during the period for which water temperature data were available.

The pool named DS from Goose Riffle Pool (Figure 4.1-1) had average water temperatures exceeding the water temperature index value of 15.6°C (60°F) approximately 78.3 percent of the time (i.e., 94 of the 120 analyzed dates from July 4 to October 31, 2003), with exceedance occurring from July 4 through September 8, and from September 13 through October 9. Average water temperatures exceeded the water temperature index value of 17.8°C (64°F) approximately 29.2 percent of the time (i.e., 35 of the 120 analyzed dates from July 4 to October 31, 2003), with exceedance occurring from July 10 through July 13, from July 16 through July 21, from July 23 through August 1, from August 6 through August 16, and from August 28 through August 31. Average water temperatures did not exceed the water temperature index value of 20.0°C (68°F) during the period for which water temperature data were available.

The pool named DS from Project Boundary Pool (Figure 4.1-1) had average water temperatures exceeding the water temperature index value of 15.6°C (60°F) approximately 79.2 percent of the time (i.e., 95 of the 120 analyzed dates from July 4 to October 31, 2003), with exceedance occurring from July 4 through September 8, and from September 13 through October 10. Average water temperatures exceeded the water temperature index value of 17.8°C (64°F) approximately 32.5 percent of the time (i.e., 39 of the 120 analyzed dates from July 4 to October 31, 2003), with exceedance occurring from July 10 through July 14, from July 16 through August 1, from August 6 through August 17, and from August 27 through August 31. Average water temperatures exceeded the water temperature index value of 20.0°C (68°F) during six days, from June 22 through 27, 2003.

The pool named NR Gridley Pool (Figure 4.1-1) had water temperatures that exceeded the water temperature index value of 15.6°C (60°F) approximately 80 percent of the time (i.e., 96 of the 120 analyzed dates from July 4 to October 31, 2003), with exceedance occurring from July 4 through September 8, and from September 12 through October 10. The water temperature index value of 17.8°C (64°F) was exceeded approximately 33.3 percent of the time (i.e., 40 of the 120 analyzed dates from July 4 to October 31, 2003) with exceedance occurring from July 10 through August 1, from August 6 through 17, and from August 27 through August 31. Average water temperatures exceeded the water temperature index value of 20.0°C (68°F) during two days, June 26 and 27, 2003.

The thermal regime of the pool named DS from Junkyard Riffle Pool (Figure 4.1-1) was represented by thermograph data available from July 10 through October 31, 2003. Average water temperatures exceeded the water temperature index value of 15.6°C (60°F) approximately 78.9 percent of the time (i.e., 90 out of 114 sampled dates), with exceedance occurring from July 10 through September 8, and from September 12 through October 10, 2003. Mean daily water temperatures exceeded the water temperature index value of 17.8°C (64°F) approximately 41.2 percent of the time (i.e., 47 out of 114 sampled dates), with exceedance occurring from July 10 through August 1, from August 5 through August 18, from August 26 through September 2, and on September 22 and 23. Average water temperatures did not exceed the water temperature index value of 20.0°C (68°F) during the period for which water temperature data were available.

The thermal regime of the pool named US from Honcut C Pool (Figure 4.1-1) was represented by thermograph data available from June 26 through September 18, and from October 4 through October 31, 2003. Average water temperatures exceeded the water temperature index value of 15.6°C (60°F) approximately 79.6 percent of the time (i.e., 90 out of 113 sampled dates), with exceedance occurring from June 26 through September 8, and from September 12 through 18, from October 4 through October 10, and on October 12. Mean daily water temperatures exceeded the water temperature index value of 17.8°C (64°F) approximately 46.9 percent of the time (i.e., 53 out of 113 sampled dates), with exceedance occurring from June 26 through July 1, from July 9 through August 1, from August 5 through August 18, from August 26 through September 2, and on October 6. Average water temperatures exceeded the water temperature index value of 20.0°C (68°F) approximately 1.8 percent of the time, which corresponded to two days (June 26 and 27, 2003).

The thermal regime at the pool named Singh AB Riviera Road Pool (Figure 4.1-1), which was the most downstream pool in which thermograph water temperature data were recorded, was represented by thermograph data available from April 18 through July 8, from July 25 through September 16, and from October 4 through October 31, 2003. Average water temperatures exceeded the water temperature index value of 15.6°C (60°F) approximately 78.05 percent of the time (i.e., 128 out of 164 sampled dates), with exceedance occurring from April 18 through April 20, on May 1, from May 5 through July 8, from July 25 through September 8, from September 12 through September 16, from October 4 through October 10 and on October 12, 2003. Mean daily water temperatures exceeded the water temperature index value of 17.8°C (64°F) approximately 48.2 percent of the time (i.e., 79 out of 164 sampled dates), with exceedance occurring from May 13 through May 18, from May 20 through May 23, from May 26 through May 29, from May 31 through July 2, from July 25 through August 1, from August 4 through August 18, from August 26 through September 2, and on October 6. Average water temperatures exceeded the water temperature index value of 20.0°C (68°F) approximately 7.3 percent of the time (i.e., 12 out of 164 sampled dates), with exceedance occurring on June 3, from June 16 through June 18, and from June 21 through June 28.

7-day moving average thermograph time series data

Analysis of the percentage of the weekly or 7-day moving average (average of the mean daily water temperatures from seven consecutive days, performed on a rolling basis) water temperature data exceeding the water temperature index values is very similar to the result of the analysis of the mean daily water temperatures exceeding the water temperature index values. Analysis of complete 7-day moving average data (e.g., July 10 to October 31, 2004) indicates that 11 out of 13, and 10 out of 13 sampled pools had mean weekly water temperatures at some time during the period of record above 15.6°C (60°F) and 17.8°C (64°F), respectively (Figure 5.2-6).

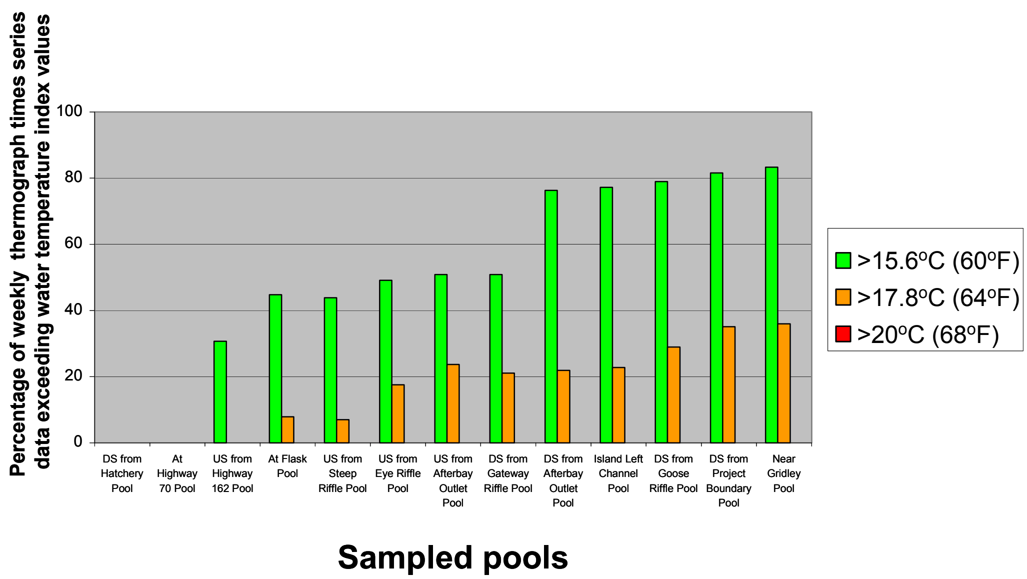

Figure 5.2-4. Percentage of time that 7-day moving average water temperatures exceeded each water temperature index value in some sampled pools for which complete time series data were available from July 4 through October 31, 2003 during the 2003 spring-run Chinook salmon immigration and holding period.

6.0 ANALYSES

6.1 EXISTING CONDITIONS/ENVIRONMENTAL SETTING

Tasks 1D and 1E are subtasks of SP-F10, *Evaluation of Project Effects on Salmonids and their Habitat in the Feather River Below the Fish Barrier Dam*, and fulfill a portion of the FERC application requirements by evaluating the effects of water temperatures on early upmigrating (spring-run) adult Chinook salmon production (along with other study plans), holding habitat, and habitat use patterns in the lower Feather River.

6.1.1 Interim Report

6.1.1.1 Pool Profile Water Temperature Data

During the 2002 adult Chinook salmon immigration and holding period, which extends from March through October, DWR conducted water temperature monitoring studies in potential holding pools in the lower Feather River, from the Fish Barrier Dam to the confluence with the Sacramento River. During this period, water temperature profiles were collected from the potential holding pools identified in Figure 4.1-1 sampled biweekly from April 30 to October 25, 2002. Due to uncontrollable circumstances, some data were lost prior to analysis. Table 5.1-1 shows available mean water column temperatures recorded during the 2002 spring-run Chinook salmon immigration and holding period. Pool profile water temperature data collected from pools in the lower Feather River during the 2002 spring-run Chinook salmon immigration and holding period are presented in Appendix D.

6.1.2 Final Report

During the 2003 adult Chinook salmon upmigrating and holding season DWR conducted water temperature monitoring studies in potential spring-run Chinook salmon holding pools in the lower Feather River from the Fish Barrier Dam to the confluence with the Sacramento River. Available water temperature data included biweekly water column profile and mean daily thermograph data. Water temperature profile sampling took place in the same pools that were sampled in 2002 while thermographs were installed in many of the same pools as those where profile sampling was conducted as well as additional pools. Table 5.2-1 shows mean water column temperatures collected during the 2003 spring-run Chinook salmon immigration and holding period. Pool profile water temperature data collected from pools in the lower Feather River during the 2003 spring-run Chinook salmon immigration and holding period are presented in Appendix A.

Concerns regarding potential bias introduced by incomplete thermograph time series precluded comparative analysis between thermographs with complete data sets and those thermographs with incomplete data sets. However, each thermograph data set was analyzed individually. The exceedance percentages of mean water column temperatures for those thermographs with full data sets (i.e., containing all data from July 4 to October 31, 2003) were compared to determine the proportion of water temperature data that exceeded each water temperature index value during the 2003 sampling period. Pool water temperature data collected from thermographs in the lower Feather River in the 2003 spring-run Chinook salmon immigration and holding period are presented in Appendix B.

6.2 PROJECT RELATED EFFECTS

6.2.1 Interim Report

Because limited data were available in 2002, it was not possible to draw definitive conclusions about water temperatures in potential spring-run Chinook salmon holding pools during the 2002 spring-run Chinook salmon immigration and holding period. However, mean water column temperatures in Pools 1-1, 1-2, and 1-3 remained within the range defined as suitable during the time period for which data were available except for one sampling date. Mean water column temperatures in all remaining pools except for Pools 3-3, 4-1, and 4-4 were within the range defined as suitable, the range in which potential sublethal effects could occur, or the defined upper incipient lethal range for all dates within the period for which data were available. Mean water column temperatures within Pools 3-3, 4-1, and 4-4 remained within the range in which potential sublethal effects could occur, or the defined upper incipient lethal range for all dates within the period for which data were available. Table 5.1-1 shows all available potential spring-run Chinook salmon holding pool water temperature data collected during sampling efforts in 2002.

Under normal project operating conditions, from the pool named Upstream from Afterbay Outlet Pool (Pool 2-1) (Figure 4.1-1) downstream to the pool named Near Verona Pool (Pool 4-5) (Figure 4.1-2), mean water column temperatures exceeded each of the water temperature index values during some sampling events. In the LFC, the lowest percentage of mean water column temperatures exceeding the water temperature index value of 15.6°C (60°F) occurred in the most upstream pools (Reach 1). Percentages of mean water column temperatures exceeding the water temperature index value of 17.8°C (64°F) progressively increased downstream. Therefore the risk of increased incidence of disease in adults and increased opportunity for embryonic developmental abnormalities would be expected to decrease as immigration proceeds in the lower Feather River (i.e. in the upper portion of the LFC). Conversely, the risk of increased incidence of disease in adults and increased opportunity for embryonic developmental abnormalities would be expected to increase in individuals holding farther downstream. Additionally, no mean water column temperatures at or above 21°C (69.8°F), the water temperature reported to potentially create a thermal migration barrier, were observed among available water temperature data.

6.2.2 Final Report

6.2.2.1 Pool Profile Water Temperature Data

Water temperature profile data were collected during 13 sampling events in 2003 between March 20 and October 2 from the same 16 potential spring-run Chinook salmon holding pools sampled in 2002. However, data collected from Pool 3-2 were not analyzed because data were only collected once from the pool (Table 5.2-1).

During the 2003 spring-run Chinook salmon immigration and holding period, an estimated total of 66 percent of mean water temperature profile data obtained from 15 pools (although Pool 3-2 was one of the original pools sampled in 2002, it was not included in the 2003 analysis because it was only sampled once during 2003) in the lower Feather River exceeded the index value of 15.6°C (60°F). Forty-eight percent of mean water temperature profile data obtained from 11 pools exceeded the index value of 17.8°C (64°F). An estimated total of nine percent of mean water temperature profile data obtained from 10 pools in the lower Feather River exceeded the index value of 20.0°C (68°F). Approximately five percent of mean water temperature profile data exceeded the reported thermal barrier of 21°C (70°F) during the time for which data were available during the 2003 spring-run Chinook salmon immigration and holding period.

Based on available literature, increased incidence of disease, developmental abnormalities, increased in-vivo egg mortality, and temporary cessation of migration could occur due to elevated water temperatures in some areas of the lower Feather River. However, results of the analysis of pool profile water temperature data should be utilized carefully because the data do not indicate the duration of elevated water temperatures in any individual pool.

6.2.2.2 Pool Thermograph Data

An estimated total of 51 percent of the mean daily thermograph water temperature data in 13 out of 24 pools, and 61 percent of the 7-day moving average (weekly) of mean thermograph water temperature data in 11 out of 24 pools exceeded the water temperature index value of 15.6°C (60°F). Twenty-two percent of daily and weekly mean thermograph water temperature data in 10 out of 24 pools exceeded the index value of 17.8°C (64°F). Daily and weekly mean thermograph water temperature data never exceeded the index value of 20°C (68°F) during the 2003 adult spring-run Chinook salmon immigration and holding period in the lower Feather River. In the LFC, the lowest percentage of water temperature data exceeding 15.6°C (60°F) occurred in the most upstream pools. The percentage of water temperature data exceeding 17.8°C (64°F) increased with distance downstream with the highest percentage of exceedance occurring in the most downstream pools.

Based on available literature, and analysis of water temperature data collected from thermographs in the lower Feather River, the potential exists in some areas of the river during some portions of immigration and holding period for increased incidence of disease and mortality, in-vivo egg mortality, and developmental abnormalities occurring. Overall, however, results of thermograph data analyses indicate that water temperatures generally are below those reported in the literature where profound individual or population effects occur. Additionally, daily and weekly mean water temperatures generally did not exceed the water temperatures reported to inhibit migration (21°C to 22°C (Berman and Quinn 1991)). However, the results of analysis of thermograph water temperature data should be utilized carefully due to inherent data limitations.

7.0. REFERENCES

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State of California
The Resources Agency
Department of Water Resources

FINAL REPORT
EVALUATION OF OROVILLE FACILITIES OPERATIONS ON WATER TEMPERATURE-RELATED EFFECTS ON PRE-SPAWNING ADULT CHINOOK SALMON AND CHARACTERIZATION OF HOLDING HABITAT
SP-F10, TASKS 1D AND 1E

APPENDIX A
WATER TEMPERATURE PROFILE DATA COLLECTED IN FEATHER RIVER POOLS
(MARCH 2003 THROUGH OCTOBER 2003)

Oroville Facilities Relicensing
FERC Project No. 2100

JUNE 2004

Pool 1-1
Downstream from Fish Barrier Dam

	3/21/2003	4/25/2003	5/16/2003	5/30/2003	6/16/2003	6/30/2003	7/10/2003	7/25/2003	8/6/2003	8/21/2003	9/4/2003	9/19/2003
Depth (m)	**Temp. (C)**	**Temp. (C)**	**Temp. (C)**	**Temp. (C)**	**Temp. (C)**	**Temp. (C)**	**Temp. (C)**	**Temp. (C)**	**Temp. (C)**	**Temp. (C)**	**Temp. (C)**	**Temp. (C)**
0.0	10.1	10.2	11.6	13.1	14.7	15.1	15.8	14.9	15.4	13.6	11.7	11.6
0.5	10.0	10.2	11.5	13.2	14.6	15.2	15.9	14.8	15.5	13.6	11.7	11.5
1.0	10.0	10.2	11.5	13.2	14.6	15.0	16.0	14.8	15.4	13.6	11.7	11.4
1.5	10.0	10.2	11.6	13.2	14.7	15.1	15.9	15.2	15.4	13.6	11.7	11.7
2.0	10.0	10.2	11.5	13.1	14.7	15.1	15.8	15.1	15.4	13.6	11.7	11.4
2.5	10.0	10.1	11.6	13.2	14.7	15.1	15.8	14.8	15.4	13.5	11.7	11.6
3.0	10.0	10.2	11.6	13.2	14.6	15.0	16.0	14.9	15.4	13.5	11.7	11.5
3.5	10.0	10.2	11.5	13.2	14.8	15.1	16.0	14.8	15.5	13.6	11.7	11.7
4.0	10.0	10.1	11.5	13.2	14.8	15.1	15.9	14.9	15.4	13.6	11.7	11.5
4.5	10.0	10.2	11.5	13.1	14.8	15.1	15.9	14.9	15.4	13.6	11.7	11.5
5.0	10.0	10.1	11.5	13.1	14.6	15.2	15.9	15	15.4	13.6	11.7	11.4
5.5	10.0	10.2	11.5	13.2	14.6	15.1	15.8	14.9	15.4	13.5	11.7	11.8
6.0	10.0	10.2	11.5	13.1	14.6	15.1	16.0	14.8	15.5	13.6	11.7	11.6
6.5			11.5	13.3		15.1		14.9	15.4	13.5	11.7	11.5
Mean	**10.0**	**10.2**	**11.5**	**13.2**	**14.7**	**15.1**	**15.9**	**14.9**	**15.4**	**13.6**	**11.7**	**11.6**

Pool 1-2
Upstream from Hatchery Pool

	3/21/2003	4/25/2003	5/16/2003	5/30/2003	6/16/2003	6/30/2003	7/10/2003	7/25/2003	8/6/2003	8/21/2003	9/4/2003	9/19/2003
Depth (m)	**Temp. (C)**	**Temp. (C)**	**Temp. (C)**	**Temp. (C)**	**Temp. (C)**	**Temp. (C)**	**Temp. (C)**	**Temp. (C)**	**Temp. (C)**	**Temp. (C)**	**Temp. (C)**	**Temp. (C)**
0.0	10.0	10.3	11.7	13.1	14.8	15.1	15.8	14.9	15.5	13.6	11.8	11.5
0.5	10.0	10.3	11.8	13.3	14.7	15.1	16.1	15.0	15.5	13.6	11.8	11.5
1.0	10.0	10.4	11.7	13.2	14.7	15.1	15.8	15.1	15.5	13.6	11.9	11.5
1.5	10.0	10.3	11.6	13.2	14.7	15.1	15.9	15.0	15.5	13.6	11.9	11.6
2.0	10.0	10.3	11.7	13.1	14.8	15.1	15.8	15.4	15.5	13.6	11.8	11.5
2.5	10.0	10.3	11.6	13.1	14.7	15.1	15.8	15.2	15.5	13.6	11.8	11.6
3.0	10.0	10.4	11.6	13.2	14.8	15.1	16.0	15.2	15.5	13.6	11.8	11.7
3.5	10.0	10.3	11.7	13.2	15.0	15.1	15.9	15.0	15.5	13.6	12.0	11.5
4.0	10.0	10.3	11.8	13.1	14.7	15.1	15.8	15.5	15.5	13.6	11.8	11.5
4.5	10.1	10.3	11.6	13.2	14.8	15.1	15.8	15.0	15.6	13.6	11.8	11.6
5.0	10.0	10.3	11.6	13.2	14.8	15.1	16.0	15.0	15.5	13.6	11.8	11.6
5.5	10.0	10.3	11.6	13.1	14.7	15.2	15.8	15.0	15.5	13.6	11.8	11.6
6.0	10.0	10.3	11.6	13.2	14.7	15.1	15.8	15.3	15.6	13.6	11.8	11.5
6.5	10.1	10.4	11.6	13.1		15.2	15.8	14.9	15.5	13.6	11.9	11.5
7.0	10.0	10.4						14.9			11.8	
Mean	**10.0**	**10.3**	**11.7**	**13.2**	**14.8**	**15.1**	**15.9**	**15.1**	**15.5**	**13.6**	**11.8**	**11.6**

Pool 1-3
Downstream from Hatchery

	3/21/2003	4/25/2003	5/16/2003	5/30/2003	6/16/2003	6/30/2003	7/10/2003	7/25/2003	8/6/2003	8/21/2003	9/4/2003	9/19/2003
Depth (m)	**Temp. (C)**	**Temp. (C)**	**Temp. (C)**	**Temp. (C)**	**Temp. (C)**	**Temp. (C)**	**Temp. (C)**	**Temp. (C)**	**Temp. (C)**	**Temp. (C)**	**Temp. (C)**	**Temp. (C)**
0.0	9.7	10.5	12.2	14.1	15.8	15.7	16.8	15.5	15.8	13.8	12.6	12.2
0.5	9.7	10.5	12.1	14.1	15.5	15.6	16.7	15.5	15.9	13.8	12.6	12.1
1.0	9.7	10.5	12.2	14.1	15.5	15.6	16.6	15.6	15.9	13.8	12.6	12.3
1.5	9.7	10.5	12.2	14.4	15.6	15.6	16.6	15.7	15.9	13.8	12.6	12.1
2.0							16.6	15.6				
Mean	**9.7**	**10.5**	**12.2**	**14.2**	**15.6**	**15.6**	**16.7**	**15.6**	**15.9**	**13.8**	**12.6**	**12.2**

Pool 1-4
Upstream from Highway 162 Bridge

	3/21/2003	4/25/2003	5/16/2003	5/30/2003	6/16/2003	6/30/2003	7/10/2003	7/25/2003	8/6/2003	8/21/2003	9/4/2003	9/19/2003
Depth (m)	**Temp. (C)**	**Temp. (C)**	**Temp. (C)**	**Temp. (C)**	**Temp. (C)**	**Temp. (C)**	**Temp. (C)**	**Temp. (C)**	**Temp. (C)**	**Temp. (C)**	**Temp. (C)**	**Temp. (C)**
0.0	9.8	11.0	13.1	15.9	16.6	15.8	16.9	16.0	15.9	13.9	13.4	13.3
0.5	9.9	11.0	13.2	15.1	16.7	16.2	17.3	16.6	15.7	13.9	13.2	13.0
1.0	9.8	10.9	13.2	14.7	16.9	15.7	16.9	16.4	15.7	13.9	13.2	13.2
1.5	9.8	11.0	13.0	14.8	16.6	15.6	16.9	16.3	15.7	13.8	13.3	13.0
2.0	9.8	10.9	13.4	14.8	16.6	15.6	16.9	16.1	15.7	13.8	13.3	13.0
2.5	9.8	10.9	13.1	15.6	17.2	15.7	17.1	16.1	15.9	13.8	13.3	13.2
3.0	9.9	10.9				15.6	17.3	16.0	15.8		13.5	
3.5						16.0						
Mean	**9.8**	**10.9**	**13.2**	**15.2**	**16.8**	**15.8**	**17.0**	**16.2**	**15.8**	**13.9**	**13.3**	**13.1**

Pool 2-1
Upstream from Afterbay Outlet Pool

	3/21/2003	4/25/2003	5/16/2003	5/30/2003	6/16/2003	6/27/2003	7/10/2003	7/25/2003	8/6/2003	8/21/2003	9/4/2003	9/19/2003
Depth (m)	**Temp. (C)**	**Temp. (C)**	**Temp. (C)**	**Temp. (C)**	**Temp. (C)**	**Temp. (C)**	**Temp. (C)**	**Temp. (C)**	**Temp. (C)**	**Temp. (C)**	**Temp. (C)**	**Temp. (C)**
0.0	10.9	11.3	14.5	16.1	18.2	18.8	18.3	17.6	17.3	15.5	16.2	14.3
0.5	11.0	11.3	14.6	16.3	18.2	18.7	18.5	17.8	17.3	15.5	16.1	14.3
1.0	10.9	11.3	14.5	16.4	18.1	18.9	18.3	17.7	17.6	15.4	16.2	14.3
1.5	10.9	11.3	14.7	16.3	18.1	18.8	18.4	17.6	17.4	15.4	16.3	14.3
2.0	11.0	11.3	14.6	16.3	18.3	18.7	18.3	17.5	17.4	15.5	16.3	14.3
2.5	11.0	11.3	14.6	16.2	18.1	18.7	18.4	17.5	17.3	15.5	16.2	14.3
3.0	11.1	11.3	14.6	16.3	18.1	18.9	18.3	17.5	17.3	15.5	16.1	14.3
3.5	10.9		14.6	16.1	18.1	18.8	18.4	17.6	17.4	15.4	16.2	14.3
4.0	10.9		14.6	16.2	18.1	18.7	18.3	17.6	17.3	15.4	16.1	14.3
4.5	11.1		14.6		18.1	18.7	18.5	17.5		15.4	16.1	14.3
5.0								17.5				
Mean	**11.0**	**11.3**	**14.6**	**16.2**	**18.1**	**18.8**	**18.4**	**17.6**	**17.4**	**15.5**	**16.2**	**14.3**

Pool 2-2
At Afterbay Outlet Pool

	3/21/2003	4/25/2003	5/16/2003	5/30/2003	6/16/2003	6/27/2003	7/10/2003	7/25/2003	8/6/2003	8/21/2003	9/4/2003	9/19/2003
Depth (m)	Temp. (C)	Temp. (C)	Temp. (C)	Temp. (C)	Temp. (C)	Temp. (C)	Temp. (C)	Temp. (C)	Temp. (C)	Temp. (C)	Temp. (C)	Temp. (C)
0.0	12.8	13.1	18.3	17.5	19.0	20.2	17.4	18.0	17.3	16.0	16.3	15.8
0.5	12.6	12.9	16.7	17.4	18.9	20.4		18.1	17.3	16.0	16.3	16.1
1.0	12.7	12.9	15.3	17.7	18.9	20.2		18.1	17.3	16.1	16.3	16.1
1.5	12.7	12.9	18.5	17.2	19.2	20.1		18.3	17.4	16.0	16.2	15.9
2.0	12.7	12.9	18.5	17.1	19.1	20.5		17.9	17.3	16.1	16.2	16.4
2.5	12.6	12.8	18.3	16.7	18.9	20.4		17.9	17.3	16.0	16.2	16.0
3.0	12.7	12.9	15.2	17.2	19.3	20.0		18.0	17.3	16.1	16.2	15.7
3.5	12.6	12.9	15.1	17.5	19.1	20.4		18.0	17.3	16.1	16.8	16.8
4.0	12.6	12.9	15.1	17.6	19.0	20.1		17.9	17.3	16.0	16.3	16.2
4.5	12.7	12.9	18.5	17.4	18.9	20.0			17.3		16.4	16.5
5.0	12.7	12.9	17.4	17.7		20.2			17.3		16.2	
5.5	12.7	12.9	18.4	16.8		20.1			17.3		16.5	
6.0	12.7	13.1	16.4	17.0		20.3			17.3			
6.5	12.6	13.0	15.5			20.1						
7.0	12.7	12.9	17.6									
7.5	12.8	12.9										
Mean	**12.7**	**12.9**	**17.0**	**17.3**	**19.0**	**20.2**	**17.4**	**18.0**	**17.3**	**16.0**	**16.3**	**16.2**

Pool 3-1
Downstream from Afterbay Outlet Pool

	3/21/2003	4/25/2003	5/16/2003	5/30/2003	6/16/2003	6/27/2003	7/10/2003	7/25/2003	8/6/2003	8/22/2003	9/4/2003	9/19/2003
Depth (m)	Temp. (C)	Temp. (C)	Temp. (C)	Temp. (C)	Temp. (C)	Temp. (C)	Temp. (C)	Temp. (C)	Temp. (C)	Temp. (C)	Temp. (C)	Temp. (C)
0.0		12.9	18.5	17.8	19.0	21.2	17.2	17.7	17.6	15.7	16.9	16.2
0.5		13.0	18.5	17.8	18.9	21.0	17.2	17.7	17.5	15.7	17.0	16.2
1.0		12.9	18.5	17.8	18.9	21.1	17.1	17.7	17.7	15.7	16.8	16.1
1.5		12.9	18.5	17.9	18.9	20.9	17.1	17.7	17.6	15.7	16.8	16.1
2.0			18.5	17.9	18.9	20.9	17.2	17.7	17.9	15.7	16.7	16.1
2.5				17.9		21.1	17.1	17.7	17.8	15.7	16.9	16.1
3.0								17.8	17.5	15.7		
3.5										15.7		
4.0												
Mean		**12.9**	**18.5**	**17.9**	**18.9**	**21.0**	**17.2**	**17.7**	**17.7**	**15.7**	**16.9**	**16.1**

Pool 3-2
Near Mile Long Pool

	3/20/2003	4/25/2003	5/16/2003	5/30/2003	6/16/2003	6/27/2003	7/10/2003	7/25/2003	8/6/2003	8/22/2003	9/4/2003	9/19/2003
Depth (m)	**Temp. (C)**	**Temp. (C)**	**Temp. (C)**	**Temp. (C)**	**Temp. (C)**	**Temp. (C)**	**Temp. (C)**	**Temp. (C)**	**Temp. (C)**	**Temp. (C)**	**Temp. (C)**	**Temp. (C)**
0.0	14.7											
0.5	14.7											
1.0	14.7											
Mean	**14.7**											

Pool 3-3
Downstream from Project Boundary Pool

	3/20/2003	4/25/2003	5/16/2003	5/30/2003	6/16/2003	6/27/2003	7/10/2003	7/25/2003	8/6/2003	8/22/2003	9/4/2003	9/19/2003
Depth (m)	**Temp. (C)**	**Temp. (C)**	**Temp. (C)**	**Temp. (C)**	**Temp. (C)**	**Temp. (C)**	**Temp. (C)**	**Temp. (C)**	**Temp. (C)**	**Temp. (C)**	**Temp. (C)**	**Temp. (C)**
0.0		13.0	18.8	17.5	19.6	21.3	17.1	17.9	18.2	16.1	17.1	16.3
0.5		13.0	18.7	17.6	19.6	21.6	17.1	17.9	18.0	16.1	17.1	16.3
1.0		13.1	18.7	17.5	19.8	21.3	17.1	18.0	18.1	16.1	17.1	16.3
1.5		13.0	18.7	17.5	19.7	21.4	17.1	17.9	18.2	16.2	17.1	16.3
2.0		13.1	18.8	17.5	19.6	21.4	17.1	17.9	18.1	16.1	17.1	16.2
2.5		13.0	18.7	17.6	19.6	21.4	17.1	17.9	18.1	16.1	17.1	16.3
3.0		13.0	18.8	17.7	19.6	21.4	17.1	17.9	18.1	16.1	17.1	16.3
3.5		13.0	18.8	17.6	19.6	21.5	17.1	17.9	18.0	16.1	17.1	16.2
4.0			18.8	17.5		21.5	17.1	18.0	18.1	16.1	17.2	16.2
4.5			18.7	17.5			17.1	17.9	18.1	16.1		16.3
5.0				17.5			17.1	17.9		16.1		
5.5							17.1	17.9		16.1		
6.0							17.1			16.2		
Mean		**13.0**	**18.8**	**17.5**	**19.6**	**21.4**	**17.1**	**17.9**	**18.1**	**16.1**	**17.1**	**16.3**

Pool 3-4
Near Gridley Pool

	3/20/2003	4/25/2003	5/16/2003	5/30/2003	6/16/2003	6/27/2003	7/10/2003	7/24/2003	8/6/2003	8/22/2003	9/5/2003	9/19/2003
Depth (m)	**Temp. (C)**	**Temp. (C)**	**Temp. (C)**	**Temp. (C)**	**Temp. (C)**	**Temp. (C)**	**Temp. (C)**	**Temp. (C)**	**Temp. (C)**	**Temp. (C)**	**Temp. (C)**	**Temp. (C)**
0.0	14.2	13.0	18.3	17.2	19.4	21.4	17.1	19.1	18.4	16.1	17.7	15.9
0.5	14.2	13.1	18.3	17.2	19.4	21.6	17.1	19.1	18.5	16.2	17.7	15.9
1.0	14.2	13.1	18.4	17.3	19.7	21.4	17.1	19.1	18.4	16.1	17.7	15.9
1.5	14.2	13.1	18.4	17.2	19.4	21.3	17.1	19.1	18.3	16.2	17.7	15.9
2.0	14.4	13.1	18.3	17.3	19.4	21.4	17.1	19.1	18.3	16.2	17.7	15.9
2.5	14.2	13.1	18.3	17.2	19.4	21.4	17.1	19.1	18.4	16.2	17.8	15.9
3.0	14.2	13.1	18.3	17.2	19.4	21.5	17.1	19.1	18.3	16.2	17.6	15.9
3.5	14.5	13.1	18.3	17.2	19.5	21.6	17.1	19.2	18.3	16.2	17.6	15.9
4.0	14.4	13.1	18.4	17.2	19.5	21.5	17.1	19.1	18.3	16.1	17.6	15.9
4.5			18.4	17.2	19.4	21.4	17.1	19.1	18.3	16.1	17.6	15.9
5.0				17.2		21.5	17.1	19.1	18.3	16.2	17.7	16.0
5.5						21.8	17.1	19.1	18.3	16.1	17.6	
6.0						21.4	17.1	19.2		16.1		
6.5						21.4	17.1	19.2				
7.0								19.1				
Mean	**14.3**	**13.1**	**18.3**	**17.2**	**19.5**	**21.5**	**17.1**	**19.1**	**18.3**	**16.2**	**17.7**	**15.9**

Pool 3-5
Upstream from Honcut Creek

	3/20/2003	4/25/2003	5/16/2003	5/30/2003	6/16/2003	6/27/2003	7/9/2003	7/24/2003	8/7/2003	8/22/2003	9/5/2003	9/19/2003
Depth (m)	**Temp. (C)**	**Temp. (C)**	**Temp. (C)**	**Temp. (C)**	**Temp. (C)**	**Temp. (C)**	**Temp. (C)**	**Temp. (C)**	**Temp. (C)**	**Temp. (C)**	**Temp. (C)**	**Temp. (C)**
0.0	14.1	13.3	17.9	17.2	19.3	22.0	18.2	19.2	18.9	16.4	17.6	15.8
0.5	14.2	13.3	17.8	17.3	19.2	22.0	18.3	19.1	19.1	16.4	17.6	15.8
1.0	14.2	13.3	17.8	17.2	19.2	22.1	18.2	19.0	19.0	16.4	17.6	15.8
1.5	14.2	13.2	17.8	17.2	19.2	21.8	18.3	19.3	18.9	16.4	17.6	15.8
2.0	14.2	13.2	17.9	17.3	19.3	21.8	18.4	19.0	18.9	16.4	17.6	15.8
2.5	14.2	13.3	17.8	17.2	19.3	21.8	18.2	19.0	19.0	16.4	17.6	15.8
3.0	14.2	13.2	17.9	17.2	19.3	22.0	18.2	19.1	19.0	16.4	17.6	15.8
3.5	14.1					22.1	18.2	19.4	19.1	16.4	17.6	
4.0						21.8	18.2	19.0				
4.5							18.2					
5.0												
Mean	**14.2**	**13.3**	**17.8**	**17.2**	**19.3**	**21.9**	**18.2**	**19.1**	**19.0**	**16.4**	**17.6**	**15.8**

Pool 4-1
At Archer Avenue Pool

	3/20/2003	4/25/2003	5/16/2003	5/30/2003	6/13/2003	6/16/2003	6/27/2003	7/9/2003	7/24/2003	8/7/2003	8/22/2003	9/5/2003	9/19/2003
Depth (m)	**Temp. (C)**	**Temp. (C)**	**Temp. (C)**	**Temp. (C)**	**Temp. (C)**	**Temp. (C)**	**Temp. (C)**	**Temp. (C)**	**Temp. (C)**	**Temp. (C)**	**Temp. (C)**	**Temp. (C)**	**Temp. (C)**
0.0	15.1	13.2	18.0	17.1	19.6	19.9	21.6	18.3	19.0	18.9	16.5	17.2	16.1
0.5	15.1	13.2	17.8	17.0	19.4	20.0	21.6	18.3	19.0	18.9	16.5	17.2	16.2
1.0	15.1	13.2	17.8	17.1	19.5	19.9	21.5	18.2	18.9	18.9	16.5	17.2	16.1
1.5	15.2	13.2	17.8	17.1	19.4	19.9	21.6	18.4	19.0	18.9	16.5	17.2	16.1
2.0	15.1	13.2	18.0	17.1	19.4	19.9	21.5	18.2	19.0	18.9	16.5	17.2	16.2
2.5	15.1	13.2	17.9	17.1	19.4	20.0	21.6	18.3	19.0	18.9	16.6	17.2	16.1
3.0		13.2	17.8	17.1	19.4	19.8	21.7	18.2	19.1	18.9	16.5	17.2	16.1
3.5		13.2	17.8	17.2	19.4		21.5	18.1	19.0	19.1	16.5	17.2	16.1
4.0		13.2	17.8	17.1	19.4		21.5	18.2	19.0	19.0	16.5	17.2	16.2
4.5		13.2	17.8	17.1	19.4		21.7	18.2	19.0	18.9	16.6	17.2	16.1
5.0			17.8				21.5	18.1	19.0	19.1	16.5	17.2	16.2
5.5							21.5	18.2	19.0	19.0	16.6	17.2	16.1
6.0												17.2	16.1
Mean	**15.1**	**13.2**	**17.8**	**17.1**	**19.4**	**19.9**	**21.6**	**18.2**	**19.0**	**19.0**	**16.5**	**17.2**	**16.1**

Pool 4-2
Upstream from Yuba River Pool

	3/20/2003	4/25/2003	5/16/2003	5/30/2003	6/13/2003	6/27/2003	7/9/2003	7/24/2003	8/7/2003	8/22/2003	9/5/2003	9/18/2003
Depth (m)	**Temp. (C)**	**Temp. (C)**	**Temp. (C)**	**Temp. (C)**	**Temp. (C)**	**Temp. (C)**	**Temp. (C)**	**Temp. (C)**	**Temp. (C)**	**Temp. (C)**	**Temp. (C)**	**Temp. (C)**
0.0	14.7	13.6	18.6	18.5	20.4	22.9	18.8	19.5	18.8	17.3	18.0	18.1
0.5	14.7	13.6	18.6	18.5	20.4	23.0	18.6	19.3	18.8	17.4	17.8	18.0
1.0	14.7	13.6	18.7	18.5	20.5	22.9	18.7	19.3	18.8	17.4	18.0	18.1
1.5	14.7	13.6	18.6	18.6	20.4	23.0	18.7	19.2	18.8	17.4	17.8	18.0
2.0		13.6	18.6	18.5	20.4	22.9	18.7	19.2	18.8	17.4	17.9	18.1
2.5			18.6	18.5			18.6	19.4	18.8	17.4		
3.0							18.7	19.6	18.8	17.3		
3.5												
4.0												
Mean	**14.7**	**13.6**	**18.6**	**18.5**	**20.4**	**22.9**	**18.7**	**19.4**	**18.8**	**17.4**	**17.9**	**18.1**

Pool 4-3
At Shanghai Bend Pool

	3/20/2003	4/25/2003	5/16/2003	5/30/2003	6/13/2003	6/27/2003	7/9/2003	7/24/2003	8/7/2003	8/22/2003	9/5/2003	9/18/2003
Depth (m)	**Temp. (C)**	**Temp. (C)**	**Temp. (C)**	**Temp. (C)**	**Temp. (C)**	**Temp. (C)**	**Temp. (C)**	**Temp. (C)**	**Temp. (C)**	**Temp. (C)**	**Temp. (C)**	**Temp. (C)**
0.0	12.5	12.7	14.9	15.9	17.5	21.3	18.5	18.7	17.9	17.1		18.2
0.5	12.5	12.6	14.9	16.1	17.5	21.1	18.4	18.6	17.8	17.1		18.1
1.0	12.5	12.7	14.8	16.0	17.5	21.1	18.5	18.6	17.8	17.1		18.3
1.5	12.5	12.7	14.8	16.1	17.5	21.0	18.5	18.7	17.8	17.1		18.3
2.0	12.5	12.7	14.8	16.3	17.5	21.0	18.4	18.8	17.8	16.9		18.3
2.5	12.5	12.7	14.8	15.9	17.5	21.0	18.4	18.7	17.9	17.1		18.2
3.0	12.5	12.7	14.8	16.1	17.5	21.0	18.4	18.9	17.8	17.1		18.2
3.5	12.5	12.7	14.9	16.0	17.5	21.0	18.3	18.8	17.8	16.9		18.1
4.0	12.5	12.7	14.9	16.1	17.5	21.1	18.3	18.6	17.8	17.1		18.1
4.5	12.5	12.7	14.8	16.2	17.5	21.0	18.4	18.8	17.9	17.1		18.1
5.0			14.9	15.9		21.2	18.4	18.6	17.9	17.1		18.2
5.5						21.1	18.4	18.6	18.0			18.1
6.0						21.1	18.3	18.7	17.8			18.5
6.5							18.3	18.6				
7.0								18.8				
Mean	**12.5**	**12.7**	**14.8**	**16.1**	**17.5**	**21.1**	**18.4**	**18.7**	**17.8**	**17.1**		**18.2**

Pool 4-4
At Star Bend Pool

	3/20/2003	4/25/2003	5/16/2003	5/30/2003	6/13/2003	6/27/2003	7/9/2003	7/24/2003	8/7/2003	8/22/2003	9/5/2003	9/18/2003
Depth (m)	**Temp. (C)**	**Temp. (C)**	**Temp. (C)**	**Temp. (C)**	**Temp. (C)**	**Temp. (C)**	**Temp. (C)**	**Temp. (C)**	**Temp. (C)**	**Temp. (C)**	**Temp. (C)**	**Temp. (C)**
0.0	12.9	12.7	14.8	15.7	17.2	21.2	18.6	18.9	18.0	17.2	18.2	18.2
0.5	12.9	12.7	14.8	15.7	17.2	21.2	18.6	19.0	18.0	17.1	18.2	18.1
1.0	12.7	12.7	14.8	15.8	17.2	21.2	18.6	18.9	18.0	17.2	18.2	18.2
1.5	12.8	12.7	14.8	15.7	17.2	21.3	18.6	19.0	18.0	17.2	18.2	18.2
2.0	12.9	12.7	14.8	15.7	17.1	21.2	18.6	19.0	18.0	17.2	18.2	18.2
2.5	12.9	12.7	14.8	15.7	17.1	21.3	18.7	19.0	18.0	17.1	18.2	18.2
3.0	12.9	12.7	14.8	15.8	17.2	21.3	18.6	19.0	18.0	17.2	18.2	18.1
3.5	12.7	12.7	14.9	15.8	17.2	21.2	18.6	19.0	18.0	17.1	18.2	18.2
4.0	12.7	12.7	14.9	15.8	17.2	21.2	18.5	19.0	18.0	17.2	18.2	18.2
4.5	12.7	12.7	14.9	15.8	17.1	21.2	18.5	19.0	18.0	17.1	18.2	18.1
5.0	12.7	12.7	14.9	15.7	17.2	21.2	18.6	19.0	18.0	17.1	18.2	18.2
5.5	12.7	12.7	14.9	15.8	17.2	21.2	18.6	19.0	18.0	17.1	18.2	18.2
6.0	12.9	12.7	14.9	15.8	17.2	21.2	18.5	19.0	18.0	17.1	18.2	18.2
6.5	12.9	12.7	14.8	15.7	17.1	21.2	18.6	19.0	18.1	17.2	18.2	18.3
7.0			14.9	15.7	17.1	21.2	18.6	19.0	18.0	17.1	18.2	18.2
Mean	**12.8**	**12.7**	**14.8**	**15.7**	**17.2**	**21.2**	**18.6**	**19.0**	**18.0**	**17.1**	**18.2**	**18.2**

Pool 4-5
Near Verona Pool

	3/20/2003	4/25/2003	5/16/2003	5/30/2003	6/13/2003	6/27/2003	7/9/2003	7/24/2003	8/7/2003	8/22/2003	9/5/2003	9/18/2003	10/2/2003
Depth (m)	**Temp. (C)**	**Temp. (C)**	**Temp. (C)**	**Temp. (C)**	**Temp. (C)**	**Temp. (C)**	**Temp. (C)**	**Temp. (C)**	**Temp. (C)**	**Temp. (C)**	**Temp. (C)**	**Temp. (C)**	**Temp. (C)**
0.0	12.9	12.9	16.1	17.9	18.0	21.4	18.5	19.2	18.6	18.0	18.6	18.3	18.8
0.5	12.9	12.9	16.1	17.9	17.9	21.4	18.5	19.2	18.6	18.0	18.6	18.3	18.8
1.0	12.9	12.9	16.1	17.9	17.9	21.4	18.5	19.2	18.6	18.0	18.6	18.3	18.8
1.5	12.9	12.9	16.1	17.9	17.9	21.4	18.5	19.2	18.6	18.0	18.5	18.3	18.8
2.0	12.9	12.9	16.1	17.9	18.0	21.4	18.5	19.2	18.6	18.0	18.6	18.3	
2.5	12.9	12.9	16.1	17.9	17.9		18.5	19.2	18.6	18.0			
3.0	12.9		16.1										
3.5	12.9		16.1										
Mean	**12.9**	**12.9**	**16.1**	**17.9**	**17.9**	**21.4**	**18.5**	**19.2**	**18.6**	**18.0**	**18.6**	**18.3**	**18.8**

State of California
The Resources Agency
Department of Water Resources

FINAL REPORT EVALUATION OF OROVILLE FACILITIES OPERATIONS ON WATER TEMPERATURE-RELATED EFFECTS ON PRE-SPAWNING ADULT CHINOOK SALMON AND CHARACTERIZATION OF HOLDING HABITAT SP-F10, TASKS 1D AND 1E

APPENDIX B
THERMOGRAPH DATA COLLECTED IN FEATHER RIVER POOLS (MARCH 2003 THROUGH OCTOBER 2003)

Oroville Facilities Relicensing
FERC Project No. 2100

JUNE 2004

	Downstream from Fish Barrier Dam Pool (1-1)			Upstream from Hatchery Pool (1-2)			Upstream from Auditorium Riffle Pool A5-1783.5			Downstream from Hatchery Pool (1-3)			At Highway 70 Pool A5-1776.5			Upstream from Highway 162 Pool (1-4)		
Date	**Max**	**Min**	**Mean**	**Max**	**Min**	**Mean**	**Max**	**Min**	**Mean**	**Max**	**Min**	**Mean**	**Max**	**Min**	**Mean**	**Max**	**Min**	**Mean**
06/01/03																		
06/02/03																		
06/03/03																		
06/04/03																		
06/05/03																		
06/06/03																		
06/07/03																		
06/08/03																		
06/09/03																		
06/10/03																		
06/11/03																		
06/12/03																		
06/13/03																		
06/14/03																		
06/15/03																		
06/16/03																		
06/17/03																		
06/18/03																		
06/19/03																		
06/20/03	14.6	13.8	14.2	14.8	14.0	14.3				15.3	13.9	14.5				16.8	14.3	15.5
06/21/03	14.3	13.7	14.0	14.4	13.8	14.1				15.2	13.8	14.3				16.7	14.1	15.3
06/22/03	14.3	13.7	14.0	14.4	13.8	14.2				15.0	13.6	14.3				16.7	14.0	15.2
06/23/03	14.8	13.7	14.0	14.9	13.8	14.2				15.0	13.6	14.3				16.7	14.0	15.1
06/24/03	15.7	13.8	14.7	15.9	14.0	14.8				15.8	13.9	14.8				17.0	14.1	15.5
06/25/03	14.8	14.0	14.4	14.9	14.1	14.6				15.5	14.2	14.8				17.3	14.8	15.9
06/26/03	14.8	13.8	14.2	15.1	14.0	14.4				15.5	13.8	14.5				17.1	14.3	15.6
06/27/03	15.4	13.7	14.5	15.4	13.8	14.7				15.8	13.8	14.8	15.3	14.5	14.9	17.3	14.4	15.7
06/28/03	15.3	14.6	14.9	15.4	14.8	15.0				16.0	14.7	15.2	15.6	15.0	15.2	17.8	15.2	16.3
06/29/03	15.4	14.3	14.8	15.4	14.4	14.9				15.8	14.2	15.1	15.5	14.9	15.2	17.5	14.9	16.0
06/30/03	15.6	14.8	15.2	15.7	14.9	15.3				16.0	14.9	15.4	15.8	15.0	15.4	17.8	15.2	16.3
07/01/03	14.9	13.4	13.9	15.1	13.7	14.0				15.0	13.8	14.3	15.5	14.9	15.1	16.7	14.9	15.7

	Downstream from Fish Barrier Dam Pool (1-1)			Upstream from Hatchery Pool (1-2)			Upstream from Auditorium Riffle Pool A5-1783.5			Downstream from Hatchery Pool (1-3)			At Highway 70 Pool A5-1776.5			Upstream from Highway 162 Pool (1-4)		
Date	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean
07/02/03	14.3	13.2	13.7	14.4	13.4	13.9				14.9	13.3	14.0	14.9	14.2	14.6	16.2	14.0	15.0
07/03/03	14.5	13.5	14.0	14.6	13.7	14.1				14.9	13.6	14.3	15.0	14.4	14.7	16.7	14.1	15.3
07/04/03	14.9	13.8	14.3	15.1	14.0	14.4	15.1	13.8	14.5	15.3	13.9	14.6	15.2	14.5	14.8	17.1	14.4	15.6
07/05/03	15.1	14.2	14.5	16.3	14.3	14.7	15.4	14.3	14.7	15.6	14.2	14.9	15.3	14.7	15.0	17.3	14.8	15.9
07/06/03	14.9	14.2	14.5	15.2	14.3	14.6	15.4	14.2	14.7	15.6	14.2	14.8	15.5	14.7	15.0	17.1	14.6	15.8
07/07/03	15.1	14.3	14.7	15.2	14.4	14.9	15.4	14.3	14.9	15.8	14.2	15.0	15.5	14.9	15.1	17.3	14.8	15.9
07/08/03	15.7	14.3	15.0	15.7	14.4	15.1	15.9	14.3	15.1	16.1	14.4	15.2	15.6	14.9	15.2	17.5	14.9	16.1
07/09/03	16.2	15.1	15.6	16.3	15.2	15.7	16.4	15.1	15.7	16.7	15.0	15.8	16.0	15.2	15.5	18.1	15.4	16.6
07/10/03	16.5	15.3	15.9	16.7	15.4	16.0	16.7	15.4	16.0	16.9	15.5	16.2	16.1	15.5	15.8	18.4	15.9	17.0
07/11/03	15.9	14.3	14.8	16.2	14.6	15.0	16.0	14.6	15.0	16.1	14.7	15.2	16.1	15.5	15.7	17.6	15.7	16.6
07/12/03	14.9	14.2	14.5	15.1	14.3	14.7	15.3	14.3	14.7	15.6	14.2	14.9	15.6	15.0	15.3	17.3	14.9	16.0
07/13/03	15.1	14.3	14.6	15.2	14.4	14.8	15.3	14.3	14.8	15.6	14.4	14.9	15.5	15.0	15.3	17.3	14.9	16.0
07/14/03	15.6	14.6	15.0	15.5	14.8	15.1	15.7	14.6	15.1	16.0	14.5	15.2	15.6	15.0	15.3	17.6	15.1	16.2
07/15/03	15.7	14.9	15.3	15.9	15.1	15.5	16.0	15.1	15.5	16.4	15.0	15.6	16.0	15.3	15.6	18.1	15.4	16.6
07/16/03	15.7	14.9	15.4	15.9	15.1	15.5	16.2	15.1	15.5	16.4	15.2	15.7	16.0	15.5	15.7	17.9	15.6	16.6
07/17/03	15.4	14.0	14.3	15.5	14.1	14.4	15.4	14.2	14.5	15.3	14.2	14.6	15.8	15.2	15.4	16.8	14.9	15.9
07/18/03	14.6	14.0	14.2	14.8	14.1	14.4	15.1	14.0	14.4	15.2	14.1	14.5	15.3	14.9	15.1	16.8	14.6	15.5
07/19/03	14.8	14.2	14.4	14.9	14.3	14.5	15.3	14.3	14.6	15.3	14.2	14.6	15.3	14.9	15.1	16.8	14.6	15.6
07/20/03	14.6	13.8	14.2	14.8	14.0	14.3				15.0	13.9	14.4	15.2	14.7	14.9	16.7	14.4	15.4
07/21/03	15.4	14.5	14.8	15.4	14.6	14.9				15.6	14.5	15.0	15.5	14.9	15.1	17.3	14.8	15.9
07/22/03	15.9	14.9	15.3	15.9	15.1	15.5				16.4	15.0	15.6	15.8	15.2	15.5	17.9	15.4	16.6
07/23/03	15.9	15.3	15.5	16.0	15.4	15.7				16.4	15.3	15.8	16.0	15.5	15.7	17.9	15.9	16.8
07/24/03	15.4	14.0	14.5	15.5	14.1	14.7				15.5	14.2	14.8	15.8	15.3	15.5	16.8	15.2	16.0
07/25/03	14.8	14.3	14.5	14.9	14.4	14.7				15.5	14.4	14.8	15.3	14.9	15.2	17.1	14.9	15.8
07/26/03	14.9	14.0	14.4	14.9	14.1	14.5				15.3	14.1	14.6	15.2	14.5	14.8	16.8	14.6	15.6
07/27/03	14.8	13.8	14.3	14.9	14.0	14.4				15.3	13.9	14.5	15.0	14.4	14.6	17.0	14.4	15.6
07/28/03	14.8	14.0	14.3	14.9	14.1	14.4				15.3	14.1	14.6	15.0	14.4	14.7	16.8	14.4	15.5
07/29/03	15.3	14.3	14.7	15.2	14.4	14.8				15.6	14.4	15.0	15.3	14.7	14.9	17.1	14.8	15.8
07/30/03	15.4	14.8	15.0	15.5	14.8	15.1				15.8	14.7	15.2	15.3	15.0	15.1	17.1	15.2	16.1
07/31/03	15.6	14.6	15.1	15.7	14.6	15.2				16.1	14.7	15.2	15.5	15.0	15.2	17.3	15.2	16.1
08/01/03	14.6	14.0	14.2	14.6	14.0	14.3				14.7	14.1	14.3	15.3	14.7	14.8	15.9	14.8	15.3

	Downstream from Fish Barrier Dam Pool (1-1)			Upstream from Hatchery Pool (1-2)			Upstream from Auditorium Riffle Pool A5-1783.5			Downstream from Hatchery Pool (1-3)			At Highway 70 Pool A5-1776.5			Upstream from Highway 162 Pool (1-4)		
Date	**Max**	**Min**	**Mean**	**Max**	**Min**	**Mean**	**Max**	**Min**	**Mean**	**Max**	**Min**	**Mean**	**Max**	**Min**	**Mean**	**Max**	**Min**	**Mean**
08/02/03	14.8	14.2	14.3	14.8	14.1	14.4				14.7	14.2	14.4	14.7	14.5	14.6	15.6	14.6	14.9
08/03/03	15.1	14.0	14.6	15.2	14.1	14.7				15.5	14.2	14.8	15.0	14.5	14.7	16.7	14.6	15.6
08/04/03	15.1	14.3	14.6	15.2	14.4	14.7				15.3	14.2	14.8	15.0	14.7	14.8	16.8	14.8	15.7
08/05/03	15.4	14.9	15.2	15.5	15.1	15.3				16.0	15.0	15.4	15.3	15.0	15.1	17.3	15.2	16.1
08/06/03				16.2	15.4	15.6				16.3	15.2	15.7	15.5	15.2	15.3	17.9	15.2	16.4
08/07/03				16.3	14.9	15.9				16.7	15.0	16.0	15.6	15.5	15.5	18.1	15.9	16.8
08/08/03				14.9	14.1	14.5				15.3	14.1	14.6	15.5	14.7	14.9	16.8	14.6	15.6
08/09/03				15.2	14.1	14.7				15.5	14.1	14.8	15.0	14.5	14.7	17.0	14.3	15.5
08/10/03				15.2	14.3	14.7				15.6	14.1	14.8	14.9	14.5	14.7	17.0	14.4	15.6
08/11/03				16.0	14.4	15.0				15.8	14.4	15.1	15.0	14.7	14.8	17.1	14.8	15.8
08/12/03				16.0	15.4	15.6				16.3	15.2	15.7	15.3	15.0	15.2	17.8	15.6	16.4
08/13/03				15.4	13.2	14.3				15.2	13.3	14.4	15.3	14.5	15.0	16.7	14.4	15.6
08/14/03				13.2	12.4	12.8				13.4	12.5	12.9	14.5	13.6	13.9	15.1	13.2	14.0
08/15/03				13.1	12.4	12.8				13.6	12.4	12.9	13.8	13.3	13.5	15.1	12.7	13.7
08/16/03				13.2	12.3	12.7				13.6	12.2	12.8	13.5	13.1	13.3	15.1	12.4	13.7
08/17/03				13.1	12.6	12.9				13.4	12.7	13.0	13.6	13.3	13.4	15.2	13.1	13.9
08/18/03				13.5	12.6	13.0				13.9	12.5	13.2	13.6	13.3	13.4	15.4	12.9	13.9
08/19/03				14.0	13.2	13.5				14.4	13.1	13.6	13.9	13.6	13.7	15.9	13.4	14.4
08/20/03				14.0	13.1	13.4	14.3	12.9	13.5	14.4	13.0	13.5	13.9	13.6	13.7	15.9	13.2	14.4
08/21/03				14.1	13.4	13.7	14.2	13.4	13.7	14.4	13.3	13.7	13.9	13.8	13.8	15.6	13.5	14.4
08/22/03				14.1	13.5	13.8	14.3	13.5	13.8	14.4	13.6	13.8	14.1	13.9	14.0	15.2	14.0	14.4
08/23/03				14.9	13.8	14.3	15.1	13.8	14.4	15.3	13.8	14.4	14.2	14.1	14.1	16.8	13.8	15.2
08/24/03				15.1	14.4	14.7	15.4	14.3	14.8	15.6	14.4	14.9	14.5	14.2	14.4	17.1	14.6	15.7
08/25/03				15.2	14.3	14.8	15.6	14.3	14.8	15.6	14.2	14.9	14.5	14.5	14.5	17.1	14.8	15.8
08/26/03				15.5	14.8	15.0	15.6	14.8	15.1	15.8	14.9	15.2	14.9	14.5	14.7	17.3	15.1	16.0
08/27/03				15.5	14.6	15.2	15.9	14.3	15.2	16.1	14.5	15.3	14.9	14.7	14.8	17.6	14.9	16.1
08/28/03				14.4	13.1	13.4	14.3	13.1	13.5	14.5	13.0	13.6	14.9	14.1	14.4	15.9	14.0	14.9
08/29/03				13.8	12.9	13.3	14.0	12.8	13.3	14.2	12.8	13.4	14.1	13.6	13.8	15.7	13.1	14.2
08/30/03				13.2	12.1	12.7	13.4	12.1	12.7	13.4	12.2	12.8	13.9	13.3	13.5	14.9	12.9	13.8
08/31/03				12.7	12.0	12.1	12.5	11.8	12.1	12.7	11.9	12.2	13.5	13.1	13.2	14.3	12.6	13.3
09/01/03				13.1	11.7	12.3	13.2	11.5	12.3	13.4	11.6	12.4	13.1	12.8	12.9	14.8	12.0	13.2

	Downstream from Fish Barrier Dam Pool (1-1)			Upstream from Hatchery Pool (1-2)			Upstream from Auditorium Riffle Pool A5-1783.5			Downstream from Hatchery Pool (1-3)			At Highway 70 Pool A5-1776.5			Upstream from Highway 162 Pool (1-4)		
Date	**Max**	**Min**	**Mean**	**Max**	**Min**	**Mean**	**Max**	**Min**	**Mean**	**Max**	**Min**	**Mean**	**Max**	**Min**	**Mean**	**Max**	**Min**	**Mean**
09/02/03				12.9	11.8	12.3	12.9	11.8	12.4	13.1	11.7	12.5	13.0	12.8	12.9	14.9	12.4	13.5
09/03/03				13.2	12.6	12.8	13.2	12.5	12.8	13.4	12.4	12.9	13.3	13.0	13.2	14.4	12.7	13.5
09/04/03				12.7	11.7	11.9	12.6	11.7	12.0	12.8	11.6	12.1	13.3	12.4	12.9	14.0	12.6	13.4
09/05/03				12.3	11.5	11.9	12.6	11.4	11.9	12.8	11.4	12.0	12.4	11.9	12.2	13.8	13.1	13.5
09/06/03				11.7	10.7	11.1	11.7	10.8	11.1	11.7	10.8	11.2	12.4	11.4	11.8	13.7	12.1	13.1
09/07/03				11.0	10.7	10.9	11.2	10.6	10.9	11.4	10.7	10.9	11.6	11.1	11.4	12.7	11.3	12.1
09/08/03				11.3	10.6	10.9	11.5	10.4	10.9	11.6	10.5	11.0	11.4	11.0	11.2	12.9	11.3	12.1
09/09/03				11.5	10.7	11.1	11.7	10.8	11.1	11.9	10.7	11.2	11.8	11.3	11.5	12.9	11.7	12.2
09/10/03				12.1	10.7	11.4	12.1	10.6	11.4	12.4	10.7	11.5	11.8	11.1	11.4	13.4	11.7	12.5
09/11/03				11.7	10.9	11.2	11.8	10.8	11.3	12.1	10.8	11.4	11.8	11.3	11.5	13.2	12.0	12.7
09/12/03				12.3	11.0	11.5	12.5	10.9	11.6	12.5	11.0	11.7	11.8	11.4	11.6	13.4	12.0	12.7
09/13/03				12.9	11.3	12.0	12.9	11.2	12.0	13.0	11.3	12.1	11.9	11.6	11.8	13.7	12.3	13.0
09/14/03				12.9	11.8	12.4	13.1	11.8	12.4	13.3	11.7	12.5	12.4	11.9	12.1	13.8	12.7	13.4
09/15/03				12.9	12.3	12.6	13.1	12.1	12.6	13.3	12.2	12.6	12.7	12.4	12.4	14.0	12.9	13.5
09/16/03				12.7	12.1	12.4	12.9	12.0	12.5	13.0	12.1	12.5	12.7	12.4	12.5	13.8	13.1	13.5
09/17/03				13.4	12.3	12.7	13.4	12.1	12.7	13.4	12.2	12.7	12.7	12.4	12.5	14.0	12.9	13.5
09/18/03				12.4	11.2	11.5	12.5	11.2	11.6	12.5	11.3	11.7	12.7	11.8	12.1	13.7	13.1	13.3
09/19/03				11.5	10.9	10.8	11.7	10.9	11.2	11.7	10.8	11.3	11.9	11.4	11.6	13.4	11.7	12.6
09/20/03				11.7	10.9	11.2	11.8	10.8	11.2	12.1	10.8	11.3	11.8	11.3	11.5	13.7	11.0	12.1
09/21/03				12.1	11.0	11.6	12.3	10.9	11.6	12.5	11.0	11.7	11.9	11.4	11.6	13.8	11.2	12.4
09/22/03				12.3	11.5	11.9	12.5	11.4	11.9	12.7	11.3	12.0	12.1	11.8	11.9	14.1	11.7	12.7
09/23/03				11.8	11.3	11.6	12.0	11.4	11.6	12.4	11.3	11.7	12.1	11.8	11.9	13.8	11.8	12.6
09/24/03				11.8	11.2	11.5	11.8	11.1	11.4	12.2	11.1	11.5	11.9	11.6	11.7	13.4	11.3	12.3
09/25/03				12.1	11.3	11.7	12.1	11.2	11.7	12.4	11.3	11.7	12.1	11.6	11.8	13.5	11.5	12.5
09/26/03				11.8	11.3	11.6	12.0	11.2	11.6	12.2	11.3	11.7	12.1	11.8	11.9	13.5	11.7	12.5
09/27/03				12.0	11.3	11.6	12.1	11.2	11.6	12.2	11.1	11.7	12.1	11.6	11.8	13.5	11.5	12.3
09/28/03				12.1	11.5	11.8	12.3	11.5	11.8	12.5	11.4	11.9	12.1	11.8	11.9	13.8	11.7	12.6
09/29/03				12.1	11.3	11.7	12.3	11.4	11.7	12.5	11.4	11.8	12.1	11.8	11.9	13.7	11.7	12.5
09/30/03				11.8	11.2	11.5	12.0	11.1	11.5	12.2	11.1	11.6	11.9	11.6	11.7	13.5	11.5	12.3
10/01/03				11.8	11.2	11.4	11.8	11.1	11.4	12.1	11.1	11.5	11.9	11.6	11.7	13.2	11.5	12.2
10/02/03				11.8	11.2	11.5	12.0	11.1	11.5	12.1	11.1	11.5	11.9	11.6	11.7	13.1	11.5	12.3

	Downstream from Fish Barrier Dam Pool (1-1)			Upstream from Hatchery Pool (1-2)			Upstream from Auditorium Riffle Pool A5-1783.5			Downstream from Hatchery Pool (1-3)			At Highway 70 Pool A5-1776.5			Upstream from Highway 162 Pool (1-4)		
Date	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean
10/03/03				11.8	11.3	11.5	11.8	11.2	11.5	12.1	11.1	11.5	11.9	11.6	11.7	13.4	11.5	12.3
10/04/03	11.8	11.2	11.5	12.0	11.3	11.6	12.0	11.2	11.5	12.2	11.1	11.6	11.8	11.6	11.7	13.4	11.5	12.3
10/05/03	12.2	11.5	11.8	12.3	11.5	11.9	12.5	11.4	11.9	12.7	11.4	11.9	12.1	11.8	11.9	13.8	11.7	12.5
10/06/03	11.8	11.5	11.6	12.0	11.5	11.7	12.1	11.4	11.7	12.4	11.4	11.8	12.1	11.8	11.9	13.5	11.5	12.4
10/07/03	12.1	11.5	11.7	12.1	11.5	11.8	12.1	11.5	11.7	12.2	11.4	11.8	12.1	11.9	12.0	13.5	11.7	12.5
10/08/03	12.1	11.6	11.8	12.1	11.7	11.9	12.1	11.5	11.8	12.4	11.6	11.9	12.2	12.1	12.1	13.5	11.8	12.5
10/09/03	12.4	11.5	11.9	12.4	11.5	12.0	12.3	11.5	11.9	12.4	11.4	11.9	12.2	12.1	12.1	13.5	11.7	12.5
10/10/03	12.1	11.5	11.7	12.1	11.5	11.8	12.1	11.4	11.8	12.2	11.4	11.8	12.2	12.1	12.1	13.2	11.7	12.3
10/11/03	11.6	10.8	11.3	11.7	10.9	11.4	11.7	10.9	11.4	11.9	10.8	11.4	12.1	11.8	11.8	12.9	11.3	12.0
10/12/03	11.3	10.5	10.9	11.5	10.7	11.0	11.5	10.6	11.0	11.6	10.5	11.0	11.8	10.8	11.2	12.6	10.9	11.6
10/13/03	10.8	10.2	10.5	10.9	10.4	10.6	10.9	10.3	10.6	11.1	10.2	10.6	11.3	10.8	11.0	12.3	10.6	11.3
10/14/03	10.5	10.1	10.3	10.7	10.1	10.4	10.8	10.1	10.4	11.0	10.0	10.5	11.0	10.7	10.8	12.1	10.4	11.1
10/15/03	10.7	10.2	10.4	10.7	10.3	10.5	10.8	10.1	10.4	11.0	10.0	10.5	11.0	10.5	10.8	11.8	10.3	11.0
10/16/03	10.8	10.2	10.5	10.9	10.4	10.6	10.9	10.3	10.6	11.1	10.2	10.6	11.0	10.8	10.9	12.1	10.6	11.2
10/17/03	10.8	10.5	10.6	10.9	10.6	10.7	10.9	10.4	10.7	11.1	10.5	10.7	11.3	10.8	10.9	12.1	10.7	11.2
10/18/03	10.8	10.4	10.6	10.9	10.6	10.7	10.9	10.4	10.7	11.1	10.4	10.7	11.3	10.8	10.9	12.0	10.4	11.1
10/19/03	11.0	10.7	10.8	11.0	10.7	10.9	11.2	10.8	10.9	11.4	10.7	10.9	11.3	11.0	11.1	12.4	10.7	11.4
10/20/03	11.2	10.7	10.9	11.2	10.7	11.0	11.4	10.6	10.9	11.6	10.7	11.0	11.3	10.8	11.0	12.7	10.7	11.5
10/21/03	11.3	10.4	10.7	11.3	10.4	10.8	11.2	10.3	10.8	11.4	10.4	10.8	11.3	10.7	10.9	12.3	10.6	11.3
10/22/03	11.0	10.7	10.8	11.0	10.7	10.9	11.1	10.6	10.9	11.3	10.7	10.9	11.4	11.0	11.1	12.3	10.9	11.4
10/23/03	11.3	10.4	10.8	11.3	10.4	10.9	11.2	10.3	10.8	11.4	10.4	10.9	11.3	10.8	11.0	12.4	10.6	11.3
10/24/03	11.0	10.5	10.7	11.2	10.6	10.8	11.1	10.4	10.8	11.3	10.5	10.8	11.3	10.8	11.1	12.3	10.7	11.3
10/25/03	11.5	10.5	10.9	11.5	10.7	11.0	11.4	10.6	10.9	11.4	10.5	11.0	11.4	11.0	11.1	12.4	10.6	11.4
10/26/03	11.6	11.2	11.4	11.7	11.2	11.5	11.8	11.2	11.4	11.9	11.1	11.5	11.8	11.4	11.5	12.9	11.3	11.9
10/27/03	11.5	11.0	11.3	11.7	11.2	11.3	11.7	11.1	11.3	11.9	11.0	11.3	11.8	11.3	11.4	12.7	11.0	11.8
10/28/03	11.5	10.7	11.1	11.7	10.7	11.2	11.5	10.8	11.1	11.4	10.8	11.2	11.6	11.1	11.3	12.4	11.0	11.6
10/29/03	11.6	11.3	11.5	11.8	11.3	11.6	11.8	11.2	11.5	12.1	11.1	11.6	11.9	11.6	11.7	12.9	11.5	12.0
10/30/03	11.5	10.8	11.3				11.5	11.1	11.3	11.7	11.0	11.3	11.6	11.1	11.4	12.3	10.9	11.5
10/31/03	11.6	11.2	11.4				11.7	11.1	11.4	11.7	11.0	11.3	11.6	11.3	11.4	12.0	11.0	11.4

	Downstream from Matthew's Riffle Pool A5-1738.5			Upstream from Great Western Pool A5-1725.5			Granite Pool A5-1715.5			At Flask Pool A5-1711.5			Upstream from Steep Riffle Pool A5-1710.5			Downstream from Steep Riffle Pool A5-1709.5		
Date	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean
06/01/03																		
06/02/03																		
06/03/03																		
06/04/03																		
06/05/03																		
06/06/03																		
06/07/03																		
06/08/03																		
06/09/03																		
06/10/03																		
06/11/03																		
06/12/03																		
06/13/03																		
06/14/03																		
06/15/03																		
06/16/03																		
06/17/03																		
06/18/03																		
06/19/03																		
06/20/03																		
06/21/03																		
06/22/03																		
06/23/03																		
06/24/03																		
06/25/03																		
06/26/03																		
06/27/03				17.9	15.5	17.0							18.8	16.0	17.5			
06/28/03				18.1	16.2	17.4							19.4	16.5	18.0			
06/29/03				18.1	15.8	17.3							18.9	16.4	17.8			
06/30/03				18.2	16.0	17.3							19.3	16.2	17.8			

	Downstream from Matthew's Riffle Pool A5-1738.5			Upstream from Great Western Pool A5-1725.5			Granite Pool A5-1715.5			At Flask Pool A5-1711.5			Upstream from Steep Riffle Pool A5-1710.5			Downstream from Steep Riffle Pool A5-1709.5		
Date	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean
07/01/03				17.9	16.2	17.2							18.6	16.2	17.5			
07/02/03				17.4	15.1	16.4							17.8	15.1	16.6			
07/03/03				17.4	15.1	16.5				18.3	15.1	16.8	18.1	15.1	16.7	19.0	16.6	17.8
07/04/03				17.4	15.1	16.6				18.8	15.4	17.2	18.6	15.4	17.1	19.4	17.1	18.2
07/05/03				17.7	15.8	17.0				19.1	15.9	17.6	18.9	15.9	17.5	19.7	17.4	18.6
07/06/03				17.6	16.0	17.0				19.0	16.1	17.5	18.8	16.0	17.5	19.7	17.6	18.6
07/07/03				17.7	16.2	17.1				19.0	16.1	17.6	18.8	16.0	17.5	19.4	17.6	18.6
07/08/03				17.7	16.0	17.1				19.0	16.1	17.6	18.9	16.0	17.6	19.7	17.6	18.6
07/09/03				18.1	16.5	17.3	19.2	15.7	17.5	19.8	16.4	18.1	19.6	16.4	18.1	20.3	17.7	19.0
07/10/03				18.4	17.0	17.8	19.7	16.3	18.0	20.1	17.0	18.6	20.1	17.0	18.6	20.5	18.4	19.5
07/11/03				18.4	17.4	18.0	19.2	16.7	17.9	20.1	17.3	18.7	19.9	17.3	18.7	20.8	18.7	19.7
07/12/03				18.2	16.3	17.2	18.7	15.4	17.1	19.3	16.2	17.9	19.3	16.2	17.9	20.2	18.6	19.4
07/13/03				17.9	16.0	17.2	18.6	15.4	17.1	19.3	16.2	17.8	19.1	16.4	17.8	20.2	18.1	19.1
07/14/03				17.7	16.2	17.1	18.9	15.4	17.2	19.4	16.2	17.9	19.3	16.2	17.8	20.2	18.1	19.1
07/15/03				18.1	16.8	17.5	19.2	15.9	17.6	19.8	16.5	18.3	19.7	16.5	18.2	20.5	18.2	19.3
07/16/03				18.2	17.0	17.7	19.2	16.0	17.6	19.8	16.9	18.4	19.6	16.8	18.3	20.2	18.4	19.4
07/17/03				18.1	16.6	17.4	18.4	15.9	17.1	19.3	16.4	17.8	19.3	16.4	17.8	20.2	18.1	19.1
07/18/03				17.6	15.5	16.6	18.1	14.8	16.4	18.8	15.3	17.1	18.6	15.3	17.1	19.4	17.4	18.5
07/19/03				17.4	16.0	16.7	18.3	15.1	16.5	18.8	15.4	17.2	18.6	15.4	17.1	19.2	17.3	18.3
07/20/03				17.3	15.8	16.7	17.9	14.9	16.4	18.5	15.4	17.1	18.4	15.4	17.1	19.0	17.3	18.2
07/21/03				17.7	15.7	16.8	18.7	15.1	16.8	19.3	15.6	17.4	19.1	15.6	17.4	19.5	17.4	18.4
07/22/03				17.9	16.5	17.3	19.2	15.9	17.5	19.8	16.5	18.2	19.7	16.5	18.2	20.3	18.1	19.1
07/23/03				18.1	17.1	17.6	19.2	16.3	17.9	19.9	17.3	18.6	19.7	17.3	18.6	20.3	18.7	19.5
07/24/03				18.1	17.0	17.5	18.1	16.2	17.1	19.0	16.7	17.8	18.8	16.5	17.8	19.9	18.4	19.1
07/25/03				17.4	15.8	16.7	18.4	15.2	16.7	18.8	15.7	17.3	18.8	15.7	17.3	19.4	17.6	18.5
07/26/03				17.4	15.7	16.7	18.1	14.9	16.5	18.6	15.6	17.2	18.6	15.6	17.1	19.0	17.4	18.3
07/27/03				17.6	15.7	16.7	18.1	14.9	16.5	18.6	15.4	17.2	18.6	15.4	17.1	19.4	17.1	18.3
07/28/03				17.4	15.7	16.6	18.3	14.9	16.5	18.8	15.6	17.2	18.6	15.6	17.2	19.2	17.4	18.3
07/29/03				17.6	16.0	16.7	18.6	15.1	16.8	19.3	15.6	17.4	19.1	15.6	17.4	19.7	17.4	18.5
07/30/03				17.6	16.3	17.0	18.4	15.6	17.0	19.0	16.1	17.6	18.8	16.0	17.5	19.2	17.7	18.5
07/31/03				17.6	16.2	16.9	18.6	15.6	17.0	19.0	15.9	17.5	18.9	15.9	17.5	19.4	17.4	18.4

	Downstream from Matthew's Riffle Pool A5-1738.5			Upstream from Great Western Pool A5-1725.5			Granite Pool A5-1715.5			At Flask Pool A5-1711.5			Upstream from Steep Riffle Pool A5-1710.5			Downstream from Steep Riffle Pool A5-1709.5		
Date	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean
08/01/03				17.6	16.3	16.8	17.3	15.6	16.2	18.0	16.1	16.9	18.0	16.0	16.9	18.7	17.6	18.1
08/02/03				16.6	15.7	16.1	16.2	14.8	15.4	16.5	15.1	15.8	16.5	15.1	15.8	17.7	16.5	17.0
08/03/03				17.1	15.7	16.3	18.1	14.8	16.3	18.6	15.1	16.8	18.6	14.9	16.8	18.6	16.2	17.3
08/04/03				17.3	15.8	16.6	18.1	15.1	16.6	18.6	15.6	17.1	18.4	15.6	17.1	19.0	16.8	17.9
08/05/03				17.3	15.8	16.6	18.4	15.1	16.8	19.0	15.4	17.2	18.8	15.4	17.2	18.9	16.8	17.9
08/06/03				17.6	16.2	16.9	18.7	15.6	17.1	19.1	16.1	17.6	18.9	15.9	17.6	19.2	17.1	18.3
08/07/03				17.7	16.5	17.2	19.1	15.9	17.5	19.4	16.4	18.0	19.3	16.4	17.9	19.4	17.4	18.5
08/08/03				17.7	15.8	16.9	17.8	15.4	16.7	18.3	16.1	17.3	18.1	16.0	17.2	19.0	17.4	18.3
08/09/03				17.3	14.9	16.2	17.9	14.6	16.3	18.3	15.1	16.8	18.1	15.1	16.7	18.7	16.8	17.8
08/10/03				17.1	15.4	16.4	17.9	14.9	16.4	18.3	15.4	16.9	18.3	15.4	16.9	18.7	16.6	17.8
08/11/03				17.1	15.7	16.5	17.9	14.9	16.5	18.5	15.4	17.0	18.3	15.4	16.9	18.9	16.6	17.8
08/12/03				17.4	15.8	16.8	18.7	15.4	17.0	19.1	15.7	17.4	18.9	15.6	17.3	19.0	16.8	18.0
08/13/03				17.4	16.2	16.8	17.8	15.4	16.6	18.5	15.7	17.1	18.3	15.7	17.1	18.7	16.9	18.0
08/14/03				17.0	14.9	15.7	16.2	13.8	15.0	16.7	14.3	15.6	16.7	14.3	15.6	17.9	16.3	17.2
08/15/03				15.8	14.1	15.0	16.2	13.1	14.5	16.5	13.4	15.0	16.4	13.4	15.0	17.3	15.4	16.3
08/16/03				15.7	14.1	14.9	16.2	12.9	14.5	16.4	13.4	15.0	16.4	13.4	14.9	17.1	15.0	16.0
08/17/03				15.7	14.3	15.1	16.3	13.2	14.7	16.9	13.5	15.2	16.7	13.5	15.2	17.1	15.0	16.1
08/18/03				15.7	14.4	15.1	16.3	13.2	14.7	16.7	13.5	15.2	16.7	13.5	15.2	17.1	15.0	16.2
08/19/03				16.0	15.1	15.5	16.8	13.7	15.2	17.2	14.0	15.6	17.2	14.0	15.6	17.4	15.4	16.4
08/20/03				16.0	15.1	15.6	16.8	13.7	15.2	17.0	14.1	15.7	17.0	14.1	15.7	17.4	15.5	16.6
08/21/03				16.0	15.4	15.7	16.0	13.8	15.1	16.5	14.3	15.6	16.5	14.3	15.6	16.9	15.7	16.5
08/22/03				15.8	15.7	15.8	15.7	14.4	15.0	16.1	14.8	15.5	16.0	14.8	15.4	16.8	15.7	16.3
08/23/03				16.3	15.7	15.9	17.5	14.1	15.8	17.8	14.6	16.2	17.6	14.6	16.1	17.7	15.5	16.6
08/24/03				16.8	16.2	16.4				18.5	15.6	17.0	18.3	15.6	17.0	18.4	16.3	17.4
08/25/03				17.0	16.5	16.7				18.5	15.7	17.3	18.4	15.7	17.2	18.9	16.6	17.8
08/26/03				17.1	16.6	16.9				18.6	16.1	17.3	18.4	16.0	17.3	18.9	16.9	18.0
08/27/03				17.1	16.6	16.9				18.6	16.1	17.4	18.4	16.0	17.4	19.0	16.9	18.0
08/28/03				17.1	16.6	16.9				17.8	15.9	16.9	17.8	15.9	16.9	18.6	16.9	17.9
08/29/03				16.8	15.7	16.1				16.9	14.3	15.6	16.7	14.3	15.6			
08/30/03				16.2	15.5	15.9				16.5	14.5	15.6	16.5	14.5	15.5			
08/31/03				16.0	15.4	15.6				15.7	13.8	14.9	15.7	13.8	14.8			

	Downstream from Matthew's Riffle Pool A5-1738.5			Upstream from Great Western Pool A5-1725.5			Granite Pool A5-1715.5			At Flask Pool A5-1711.5			Upstream from Steep Riffle Pool A5-1710.5			Downstream from Steep Riffle Pool A5-1709.5		
Date	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean
09/01/03				15.7	14.9	15.3				15.9	13.2	14.7	15.9	13.2	14.7			
09/02/03				15.7	15.2	15.4				16.4	13.8	15.1	16.4	13.8	15.1			
09/03/03				15.7	15.2	15.5				15.6	13.8	14.7	15.4	13.7	14.7			
09/04/03				15.5	15.4	15.5				15.9	14.1	15.0	15.9	14.1	15.0			
09/05/03				15.5	15.1	15.3				15.6	13.2	14.5	15.6	13.2	14.5			
09/06/03				15.4	14.7	15.0				15.3	12.9	14.2	15.1	13.1	14.2			
09/07/03				15.1	14.1	14.5				14.0	12.1	13.0	13.8	12.1	13.0	15.2	13.6	14.2
09/08/03										14.0	11.8	12.9	14.0	11.8	12.9	14.6	12.9	13.8
09/09/03										13.8	12.0	12.9	13.7	12.0	12.9	14.4	13.0	13.9
09/10/03	13.6	11.3	12.5							14.8	12.1	13.5	14.8	12.1	13.5	15.0	13.3	14.2
09/11/03	13.5	11.6	12.8							14.8	12.6	13.7	14.8	12.6	13.7	15.4	13.8	14.7
09/12/03	13.8	11.8	12.8							15.3	12.3	13.8	15.1	12.3	13.8	15.5	13.9	14.8
09/13/03	14.1	12.1	13.1							15.1	12.7	14.0	15.1	12.8	14.0	15.5	14.1	14.9
09/14/03	14.2	12.7	13.5							15.6	13.2	14.4	15.4	13.1	14.3	16.0	14.3	15.2
09/15/03	14.6	12.5	13.6							15.6	13.2	14.5	15.6	13.2	14.5	16.0	14.6	15.4
09/16/03	14.2	12.7	13.6							15.3	13.2	14.4	15.3	13.4	14.4	15.8	14.4	15.3
09/17/03	14.2	12.4	13.4							15.3	12.9	14.2	15.1	12.9	14.1	15.4	14.1	14.8
09/18/03	13.8	12.5	13.2							15.1	13.1	14.1	15.1	13.1	14.1	15.5	14.1	14.9
09/19/03	13.3	11.3	12.5							14.5	12.1	13.4	14.3	12.1	13.4	15.2	13.6	14.5
09/20/03	14.1	11.3	12.8							14.5	12.0	13.3	14.5	12.0	13.3	15.0	13.3	14.4
09/21/03	14.1	11.3	12.8							14.5	12.1	13.5	14.5	12.1	13.5	15.0	13.5	14.4
09/22/03	14.6	11.8	13.2							14.9	12.6	13.8	14.8	12.6	13.8	15.4	13.5	14.5
09/23/03	14.4	11.9	13.2							14.8	12.7	13.9	14.8	12.8	13.9	15.4	13.8	14.7
09/24/03	14.1	11.5	12.9							14.6	12.4	13.6	14.5	12.4	13.6	15.2	13.6	14.6
09/25/03	14.1	11.3	12.8							14.5	12.4	13.6	14.5	12.3	13.5	15.0	13.6	14.5
09/26/03	14.1	11.6	12.9							14.6	12.4	13.6	14.6	12.4	13.6	15.0	13.6	14.5
09/27/03	13.8	11.5	12.7							14.3	12.3	13.4	14.1	12.3	13.4	14.9	13.6	14.3
09/28/03	14.2	11.5	12.9							14.6	12.3	13.6	14.6	12.3	13.5	15.2	13.5	14.4
09/29/03	14.2	11.6	13.0							14.6	12.6	13.7	14.5	12.6	13.7	15.0	13.6	14.4
09/30/03	13.8	11.3	12.6							14.1	12.3	13.3	14.1	12.1	13.3	14.7	13.5	14.2
10/01/03	13.6	11.5	12.6							14.1	12.3	13.3	14.1	12.3	13.3	14.7	13.3	14.2

	Downstream from Matthew's Riffle Pool A5-1738.5			Upstream from Great Western Pool A5-1725.5			Granite Pool A5-1715.5			At Flask Pool A5-1711.5			Upstream from Steep Riffle Pool A5-1710.5			Downstream from Steep Riffle Pool A5-1709.5		
Date	**Max**	**Min**	**Mean**	**Max**	**Min**	**Mean**	**Max**	**Min**	**Mean**	**Max**	**Min**	**Mean**	**Max**	**Min**	**Mean**	**Max**	**Min**	**Mean**
10/02/03	13.9	11.3	12.5							14.1	12.0	13.1	14.1	12.0	13.1	14.6	13.2	14.0
10/03/03	14.1	11.3	12.6							14.1	12.1	13.2	14.1	12.1	13.2	14.7	13.3	14.0
10/04/03	13.9	11.6	12.7							14.3	12.3	13.4	14.1	12.3	13.4	14.7	13.5	14.2
10/05/03	14.1	11.6	12.9							14.5	12.3	13.4	14.3	12.3	13.4	14.7	13.3	14.1
10/06/03	13.9	11.6	12.8							14.3	12.4	13.5	14.1	12.4	13.5	14.7	13.5	14.2
10/07/03	14.1	11.6	12.8							14.3	12.4	13.5	14.3	12.3	13.4	14.7	13.3	14.2
10/08/03	14.1	11.6	12.9							14.5	12.4	13.5	14.5	12.3	13.5	14.9	13.3	14.2
10/09/03	13.9	11.6	12.7							14.1	12.3	13.3	14.0	12.3	13.3	14.4	13.2	13.9
10/10/03	13.5	11.3	12.5							13.7	12.0	12.9	13.7	11.8	12.9	13.8	12.4	13.2
10/11/03	13.5	11.0	12.3							13.7	11.7	12.7	13.5	11.7	12.7	13.9	12.4	13.3
10/12/03	13.0	10.8	11.9							13.2	11.7	12.5	13.2	11.5	12.5	13.5	12.4	13.1
10/13/03	12.7	10.4	11.6							12.9	11.0	12.1	12.9	11.1	12.1	13.3	11.8	12.7
10/14/03	12.5	10.2	11.4							12.7	10.9	11.9	12.8	10.9	11.9	13.2	11.8	12.5
10/15/03	12.4	10.2	11.3							12.3	10.7	11.6	12.3	10.7	11.6	12.7	11.6	12.3
10/16/03	12.7	10.2	11.5							12.9	10.7	11.8	12.8	10.7	11.8	12.9	11.5	12.3
10/17/03	12.5	10.5	11.6							12.7	11.0	12.0	12.8	10.9	11.9	13.0	11.6	12.4
10/18/03	12.5	10.4	11.5							12.6	10.9	11.8	12.4	10.9	11.8	12.9	11.6	12.3
10/19/03	12.9	10.7	11.8							12.7	11.0	12.0	12.8	11.1	12.0	12.9	11.6	12.4
10/20/03	13.0	10.7	11.9							13.2	11.2	12.2	13.1	11.2	12.2	13.2	11.8	12.6
10/21/03	12.7	10.7	11.8							12.9	11.2	12.2	12.9	11.4	12.2	13.2	11.9	12.7
10/22/03	13.2	10.8	11.9							13.1	11.3	12.2	12.9	11.4	12.2	13.3	11.9	12.7
10/23/03	12.5	10.7	11.6							13.1	11.0	12.1	13.1	11.1	12.1	13.2	11.8	12.6
10/24/03	12.1	10.5	11.3	12.9	12.4	12.7				12.9	11.0	12.0	12.8	11.1	12.0	13.0	11.9	12.6
10/25/03	12.2	10.4	11.3	12.7	12.3	12.6				13.1	11.0	12.0	12.9	10.9	12.0	13.0	11.8	12.5
10/26/03	12.7	11.2	11.9	12.9	12.6	12.7				13.5	11.5	12.5	13.4	11.5	12.5	13.5	12.1	12.9
10/27/03	12.5	11.0	11.8	13.0	12.7	12.9				13.2	11.7	12.5	13.2	11.5	12.5	13.5	12.4	13.0
10/28/03	12.4	10.8	11.7	13.0	12.9	13.0	12.9	11.2	12.1	13.1	11.5	12.4	13.1	11.5	12.3	13.5	12.2	12.9
10/29/03	12.7	11.2	11.9	13.0	12.9	13.0	13.2	11.3	12.3	13.4	11.5	12.5	13.4	11.5	12.4	13.3	12.2	12.8
10/30/03	12.1	10.5	11.3	13.0	12.4	12.7	12.3	10.7	11.6	12.4	10.9	11.8	12.3	10.9	11.7	12.6	11.6	12.2
10/31/03	11.5	10.7	11.1	12.7	12.6	12.6	11.7	10.9	11.3	11.8	11.0	11.4	11.7	10.9	11.3	12.1	11.5	11.7

	Upstream from Eye Riffle Pool A5-1708.5			Upstream from Afterbay Outlet Pool (2-1)			Downstream from Gateway Riffle Pool A5-1696.5			Downstream from Afterbay Outlet Pool (3-1)			Island Left Channel Pool A5-1665.5			Upstream from Keester Riffle Pool A5-1656.5		
Date	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean
06/01/03																		
06/02/03																		
06/03/03																		
06/04/03																		
06/05/03																		
06/06/03																		
06/07/03																		
06/08/03																		
06/09/03																		
06/10/03																		
06/11/03																		
06/12/03																		
06/13/03																		
06/14/03																		
06/15/03																		
06/16/03																		
06/17/03																		
06/18/03																		
06/19/03																		
06/20/03				18.7	16.7	17.8												
06/21/03				18.6	16.5	17.6												
06/22/03				18.4	16.3	17.5												
06/23/03				18.4	16.3	17.4												
06/24/03				18.4	16.0	17.3												
06/25/03				19.4	16.7	18.1												
06/26/03				19.4	17.1	18.3												
06/27/03	19.3	16.7	18.0	19.6	17.1	18.4												
06/28/03	19.7	17.0	18.4	20.0	17.5	18.7												
06/29/03	19.3	16.8	18.2	19.6	17.5	18.6												
06/30/03	19.4	16.7	18.1	19.6	17.1	18.5												

	Upstream from Eye Riffle Pool A5-1708.5			Upstream from Afterbay Outlet Pool (2-1)			Downstream from Gateway Riffle Pool A5-1696.5			Downstream from Afterbay Outlet Pool (3-1)			Island Left Channel Pool A5-1665.5			Upstream from Keester Riffle Pool A5-1656.5		
Date	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean
07/01/03	19.1	16.7	17.9	19.4	17.1	18.4												
07/02/03	18.1	15.7	17.1	18.6	16.3	17.6												
07/03/03	18.3	15.6	17.1	18.6	16.2	17.5	18.5	16.1	17.4									
07/04/03	18.8	15.9	17.5	19.1	16.5	17.8	19.0	16.6	17.8	17.5	16.0	16.7	17.5	16.0	16.7	17.5	16.0	16.8
07/05/03	19.1	16.4	17.9	19.6	17.0	18.3	19.3	17.1	18.2	17.6	16.2	16.9	17.8	16.2	16.9	17.8	16.2	17.0
07/06/03	18.9	16.5	17.9	19.2	17.1	18.3	19.2	17.3	18.3	17.8	16.3	17.0	17.8	16.3	17.0	17.8	16.4	17.1
07/07/03	18.9	16.7	17.9	19.4	17.1	18.3	19.2	17.3	18.3	17.5	16.3	16.9	17.5	16.3	16.9	17.6	16.4	17.0
07/08/03	19.1	16.5	17.9	19.4	17.0	18.3	19.3	17.1	18.2	18.1	16.3	17.2	18.1	16.5	17.2	18.1	16.5	17.2
07/09/03	19.7	16.8	18.4	20.0	17.3	18.7	19.8	17.4	18.6	18.1	16.5	17.3	18.1	16.5	17.3	18.1	16.7	17.4
07/10/03	20.1	17.5	18.9	20.5	17.9	19.2	20.3	18.1	19.2	18.4	16.8	17.6	18.4	16.8	17.6	18.4	17.0	17.7
07/11/03	20.2	17.8	19.1	20.7	18.3	19.5	20.5	18.4	19.5	19.2	17.3	18.1	19.2	17.3	18.1	19.2	17.3	18.2
07/12/03	19.4	17.0	18.4	19.9	17.6	18.9	19.8	17.7	18.9	18.4	17.3	18.0	18.6	17.3	18.0	18.6	17.5	18.1
07/13/03	19.4	17.0	18.3	19.7	17.5	18.7	19.7	17.7	18.7	18.7	16.7	17.6	18.7	16.7	17.6	18.8	16.8	17.7
07/14/03	19.6	16.8	18.3	19.9	17.3	18.6	19.7	17.4	18.7	17.9	16.8	17.5	17.9	16.8	17.5	18.1	17.0	17.6
07/15/03	19.9	17.2	18.6	20.0	17.6	18.9	20.0	17.7	19.0	18.1	16.8	17.4	18.1	16.8	17.4	18.1	16.8	17.5
07/16/03	19.7	17.3	18.7	20.2	17.9	19.1	20.0	18.1	19.1	19.1	17.0	17.9	19.1	17.0	17.9	19.1	17.0	18.0
07/17/03	19.4	16.8	18.2	19.9	17.5	18.8	19.8	17.6	18.8	19.2	17.6	18.3	19.2	17.6	18.3	19.2	17.8	18.4
07/18/03	18.8	15.9	17.5	19.2	16.7	18.1	19.0	16.8	18.1	18.9	17.8	18.2	18.9	17.8	18.2	18.9	17.8	18.3
07/19/03	18.8	15.9	17.5	19.1	16.7	18.0	19.0	16.8	18.0	18.1	17.3	17.7	18.3	17.3	17.7	18.3	17.5	17.8
07/20/03	18.6	16.0	17.4	19.1	16.7	17.9	18.9	16.8	17.9	18.6	17.3	17.9	18.6	17.3	17.9	18.6	17.6	18.0
07/21/03	19.1	16.0	17.7	19.4	16.7	18.1	19.2	16.8	18.1	18.4	17.0	17.6	18.4	17.0	17.7	18.6	17.1	17.8
07/22/03	19.7	17.2	18.5	20.0	17.5	18.8	20.0	17.7	18.8	18.3	16.8	17.5	18.3	16.8	17.5	18.4	16.8	17.6
07/23/03	19.9	17.8	18.9	20.2	18.3	19.3	20.2	18.4	19.3	18.4	17.1	17.7	18.4	17.1	17.7	18.4	17.1	17.8
07/24/03	19.1	17.0	18.2	19.6	17.6	18.8	19.5	17.7	18.7	19.2	17.8	18.4	19.2	17.9	18.4	19.2	17.9	18.4
07/25/03	18.9	16.2	17.7	19.2	16.8	18.1	19.2	16.9	18.1	18.4	17.5	18.0	18.4	17.5	18.0	18.4	17.6	18.1
07/26/03	18.8	16.0	17.5	19.1	16.7	18.0	19.0	16.8	18.0	18.9	17.5	18.1	18.9	17.3	18.1	18.9	17.5	18.2
07/27/03	18.8	15.9	17.5	19.1	16.7	17.9	19.0	16.6	17.9	18.7	17.8	18.3	18.7	17.8	18.3	18.9	17.9	18.4
07/28/03	18.8	16.0	17.5	19.1	16.7	18.0	19.0	16.8	18.0	18.7	17.3	18.0	18.9	17.3	18.1	18.9	17.5	18.2
07/29/03	19.1	16.0	17.7	19.4	16.7	18.2	19.3	16.8	18.1	18.4	17.1	17.7	18.4	17.1	17.7	18.6	17.3	17.8
07/30/03	18.8	16.5	17.8	19.1	17.1	18.3	19.0	17.3	18.2	18.1	17.1	17.5	18.1	17.0	17.5	18.1	17.1	17.6
07/31/03	18.9	16.2	17.7	19.2	16.8	18.1	19.2	16.8	18.1	18.3	17.3	17.7	18.3	17.3	17.7	18.4	17.3	17.8

	Upstream from Eye Riffle Pool A5-1708.5			Upstream from Afterbay Outlet Pool (2-1)			Downstream from Gateway Riffle Pool A5-1696.5			Downstream from Afterbay Outlet Pool (3-1)			Island Left Channel Pool A5-1665.5			Upstream from Keester Riffle Pool A5-1656.5		
Date	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean
08/01/03	18.1	16.5	17.2	18.7	17.1	17.8	18.7	17.1	17.8	18.4	17.5	17.9	18.3	17.5	17.9	18.4	17.6	18.0
08/02/03	16.7	15.4	16.0	17.3	15.9	16.5	17.3	15.8	16.5	18.1	16.7	17.0	18.1	16.7	17.0	18.1	16.7	17.1
08/03/03	18.6	15.3	16.9	18.7	15.7	17.1	18.7	15.7	17.1	17.9	16.0	17.0	17.9	16.0	17.0	17.9	16.2	17.1
08/04/03	18.4	15.9	17.3	18.9	16.3	17.7	18.7	16.3	17.6	17.9	16.3	17.1	17.9	16.3	17.1	17.9	16.4	17.2
08/05/03	18.8	15.7	17.3	19.1	16.2	17.7	18.9	16.3	17.6	17.9	16.7	17.3	17.9	16.7	17.3	17.9	16.7	17.4
08/06/03	18.9	16.4	17.8	19.4	16.8	18.1	19.2	16.8	18.0	18.1	17.0	17.6	18.1	17.0	17.6			
08/07/03	19.3	16.7	18.0	19.6	17.1	18.3	19.3	17.1	18.3	18.4	17.1	17.8	18.4	17.1	17.9			
08/08/03	18.3	16.4	17.5	18.7	17.0	18.0	18.7	16.9	18.0	19.4	17.5	18.3	19.4	17.5	18.3			
08/09/03	18.1	15.6	17.0	18.6	16.0	17.4	18.4	16.1	17.4	19.2	17.8	18.6	19.4	17.8	18.7			
08/10/03	18.3	15.6	17.1	18.6	16.2	17.5	18.5	16.1	17.5	19.7	18.1	18.9	19.7	18.1	18.9			
08/11/03	18.4	15.7	17.2	18.7	16.2	17.5	18.5	16.3	17.5	19.7	18.3	18.9	19.7	18.3	18.9			
08/12/03	18.9	15.9	17.5	19.2	16.2	17.8	19.0	16.3	17.7	19.6	18.6	19.0	19.6	18.6	19.0			
08/13/03	18.4	16.0	17.4	18.9	16.5	17.8	18.9	16.6	17.8	19.4	17.8	18.5	19.4	17.8	18.6			
08/14/03	17.0	14.9	16.1	17.8	15.6	16.7	17.7	15.7	16.7	18.7	18.1	18.4	18.7	18.1	18.5			
08/15/03	16.5	13.8	15.4	16.8	14.4	15.8	16.8	14.6	15.8	18.9	17.5	18.1	18.9	17.5	18.1			
08/16/03	16.4	13.8	15.3	16.8	14.3	15.7	16.6	14.4	15.7	19.1	17.3	18.0	19.1	17.3	18.1			
08/17/03	16.8	14.0	15.5	17.1	14.4	15.8	16.9	14.6	15.8	17.9	16.7	17.4	17.9	16.8	17.4			
08/18/03	16.7	14.0	15.5	17.0	14.4	15.9	16.9	14.6	15.8	17.6	16.5	17.1	17.8	16.7	17.2			
08/19/03	17.2	14.5	15.9	17.5	14.8	16.2	17.4	14.9	16.2	17.1	16.2	16.7	17.1	16.3	16.8			
08/20/03	17.0	14.6	15.9	17.3	15.1	16.3	17.3	15.0	16.3	17.5	16.2	16.7	17.5	16.2	16.7			
08/21/03	16.5	14.8	15.8	16.8	15.2	16.2	16.8	15.2	16.2	16.8	15.9	16.4	17.0	15.9	16.4			
08/22/03	16.2	15.1	15.7	16.7	15.4	16.1	16.6	15.3	16.0	16.0	15.4	15.7	16.2	15.4	15.7			
08/23/03	17.6	14.9	16.3	17.8	15.2	16.4	17.7	15.2	16.4	16.8	15.2	16.0	16.8	15.2	16.0			
08/24/03	18.3	15.9	17.2	18.6	16.3	17.4	18.5	16.3	17.4	17.5	15.9	16.7	17.5	15.9	16.7			
08/25/03	18.4	16.2	17.4	18.9	16.7	17.8	18.9	16.8	17.8	17.9	16.5	17.2	17.9	16.5	17.2			
08/26/03	18.6	16.5	17.6	18.9	16.8	17.9	18.9	16.9	17.9	17.8	16.7	17.3	17.9	16.7	17.3			
08/27/03	18.6	16.5	17.6	19.1	16.8	18.0	18.9	16.9	17.9	17.9	16.8	17.4	17.9	16.8	17.4			
08/28/03	18.0	16.4	17.3	18.6	16.8	17.7	18.5	16.9	17.7	17.9	17.1	17.6	17.9	17.1	17.6			
08/29/03	16.8	14.9	16.1	17.5	15.6	16.6	17.4	15.5	16.6	18.3	17.1	17.6	18.3	17.1	17.7			
08/30/03	16.8	14.9	16.0	17.3	15.4	16.4	17.3	15.5	16.4	18.4	17.0	17.5	18.4	17.0	17.5			
08/31/03	16.0	14.5	15.3	16.7	14.9	15.8	16.6	14.9	15.8	18.1	17.0	17.5	18.1	17.0	17.5			

	Upstream from Eye Riffle Pool A5-1708.5			Upstream from Afterbay Outlet Pool (2-1)			Downstream from Gateway Riffle Pool A5-1696.5			Downstream from Afterbay Outlet Pool (3-1)			Island Left Channel Pool A5-1665.5			Upstream from Keester Riffle Pool A5-1656.5		
Date	**Max**	**Min**	**Mean**	**Max**	**Min**	**Mean**	**Max**	**Min**	**Mean**	**Max**	**Min**	**Mean**	**Max**	**Min**	**Mean**	**Max**	**Min**	**Mean**
09/01/03	16.0	14.0	15.1	16.5	14.4	15.5	16.5	14.6	15.5	17.8	16.8	17.1	17.8	16.8	17.2			
09/02/03	16.5	14.5	15.5	17.0	14.8	15.9	16.9	14.9	15.9	18.1	16.5	17.2	18.1	16.5	17.2			
09/03/03	15.7	14.3	15.1	16.2	14.8	15.5	16.1	14.9	15.5	17.0	15.9	16.3	17.0	15.9	16.4			
09/04/03	16.4	14.5	15.4	16.7	14.9	15.7	16.6	14.9	15.7	16.5	15.6	15.9	17.0	15.6	16.0			
09/05/03	15.9	13.8	15.0	16.3	14.3	15.4	16.3	14.4	15.4	16.5	15.4	15.9	16.5	15.4	15.9			
09/06/03	15.6	13.5	14.6	16.0	14.0	15.0	16.0	14.1	15.0	16.2	15.2	15.7	16.3	15.2	15.8			
09/07/03	14.3	12.8	13.5	14.9	13.4	13.9	14.9	13.3	13.9	16.0	15.4	15.7	16.2	15.4	15.8			
09/08/03	14.1	12.3	13.3	14.6	12.7	13.6	14.4	12.7	13.6	15.9	14.9	15.3	15.9	14.9	15.4			
09/09/03	13.8	12.4	13.2	14.1	12.7	13.5	14.1	12.9	13.2	15.1	14.0	14.4	15.1	14.0	14.4			
09/10/03	14.9	12.4	13.7	15.1	12.9	14.0	15.0	12.9	13.9	14.9	14.0	14.4	14.9	14.0	14.4			
09/11/03	14.9	12.9	14.0	15.4	13.4	14.4	15.3	13.3	14.3	15.2	14.1	14.7	15.4	14.3	14.7			
09/12/03	15.3	12.8	14.1	15.6	13.2	14.5	15.5	13.3	14.4	15.4	14.6	15.0	15.6	14.4	15.1			
09/13/03	15.3	13.1	14.3	15.6	13.5	14.6	15.5	13.6	14.6	15.9	14.8	15.3	16.0	14.8	15.3			
09/14/03	15.6	13.4	14.6	15.9	13.8	14.9	15.8	13.9	14.9	16.3	14.9	15.6	16.7	14.9	15.7			
09/15/03	15.6	13.7	14.7	16.0	14.1	15.0	15.8	14.1	15.0	15.9	15.1	15.5	15.9	15.1	15.6			
09/16/03	15.4	13.7	14.6	15.7	14.1	15.0	15.7	14.1	14.9	16.3	15.4	15.9	16.3	15.4	15.9			
09/17/03	15.3	13.2	14.3	15.4	13.7	14.6	15.3	13.6	14.6	16.3	15.9	16.1	16.5	15.9	16.2			
09/18/03	15.3	13.4	14.3	15.6	13.7	14.6	15.5	13.6	14.6	16.8	15.2	16.0	17.0	15.4	16.0			
09/19/03	14.6	12.6	13.7	14.9	13.1	14.1	14.9	13.0	14.1	17.1	15.6	16.2	17.3	15.6	16.2			
09/20/03	14.6	12.3	13.6	14.9	12.9	13.9	14.9	12.9	13.9	17.8	15.9	16.6	17.8	15.9	16.7			
09/21/03	14.6	12.6	13.7	14.9	13.1	14.1	14.9	13.2	14.1	17.6	16.0	16.8	17.8	16.2	16.9			
09/22/03	14.9	12.9	14.0	15.2	13.4	14.3	15.2	13.3	14.3	18.1	16.5	17.1	18.3	16.7	17.2			
09/23/03	14.9	13.1	14.1	15.2	13.5	14.5	15.3	13.6	14.4	17.9	16.3	16.8	17.9	16.3	16.9			
09/24/03	14.6	12.8	13.9	14.9	13.4	14.2	14.9	13.3	14.2	16.8	15.9	16.2	17.1	15.9	16.3			
09/25/03	14.6	12.8	13.8	14.9	13.2	14.1	14.9	13.2	14.1	17.0	15.7	16.3	17.3	15.7	16.3	17.4	15.8	16.5
09/26/03	14.6	12.8	13.8	14.9	13.2	14.1	14.9	13.3	14.1	16.8	15.9	16.4	17.1	15.9	16.5	17.4	15.9	16.6
09/27/03	14.5	12.6	13.6	14.8	13.1	14.0	14.7	13.2	14.0	17.1	15.9	16.5	17.3	15.9	16.6	17.5	16.1	16.7
09/28/03	14.8	12.6	13.7	14.9	13.1	14.0	14.9	13.0	14.0	17.1	15.9	16.4	17.3	16.0	16.6	17.4	16.1	16.7
09/29/03	14.6	12.9	13.9	14.9	13.4	14.2	14.9	13.3	14.2	17.3	15.7	16.4	17.1	15.9	16.4	17.2	15.8	16.5
09/30/03	14.3	12.4	13.5	14.6	13.1	13.9	14.6	13.0	13.8	17.6	16.3	16.8	17.8	16.3	16.9	17.9	16.4	17.0
10/01/03	14.3	12.6	13.5	14.6	13.1	13.8	14.6	13.0	13.8	17.0	15.9	16.4	17.1	15.9	16.5	17.4	15.9	16.6

	Upstream from Eye Riffle Pool A5-1708.5			Upstream from Afterbay Outlet Pool (2-1)			Downstream from Gateway Riffle Pool A5-1696.5			Downstream from Afterbay Outlet Pool (3-1)			Island Left Channel Pool A5-1665.5			Upstream from Keester Riffle Pool A5-1656.5		
Date	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean
10/02/03	14.1	12.3	13.3	14.4	12.7	13.6	14.4	12.7	13.6	16.8	15.9	16.3	17.0	15.9	16.4	17.4	15.9	16.5
10/03/03	14.3	12.4	13.4	14.6	12.7	13.7	14.4	12.9	13.7	16.7	15.6	16.1	16.5	15.7	16.2	16.7	15.8	16.3
10/04/03	14.3	12.6	13.6	14.6	13.1	13.9	14.6	13.2	13.8	17.0	15.7	16.3	17.0	15.7	16.3	17.1	15.8	16.4
10/05/03	14.5	12.4	13.6	14.6	12.9	13.9	14.6	13.0	13.8	17.8	16.2	16.9	17.9	16.3	17.0	18.0	16.3	17.1
10/06/03	14.3	12.8	13.7	14.6	13.2	14.0	14.6	13.2	13.9	17.6	16.3	16.9	17.6	16.5	17.0	17.7	16.4	17.1
10/07/03	14.5	12.6	13.6	14.6	13.1	13.9	14.6	13.0	13.9	17.8	15.9	16.7	17.8	16.0	16.8	17.9	16.1	16.9
10/08/03	14.5	12.6	13.6	14.8	12.9	13.9	14.6	13.0	13.9	17.0	16.0	16.4	17.3	16.0	16.5	17.5	15.9	16.6
10/09/03	14.1	12.4	13.4	14.4	12.9	13.7	14.4	12.9	13.6	17.1	15.6	16.2	17.3	15.6	16.3	17.5	15.6	16.4
10/10/03	13.7	12.0	12.9	13.8	12.3	13.1	13.8	12.2	13.0	15.9	14.8	15.3	16.0	14.8	15.4	15.9	14.8	15.4
10/11/03	13.7	11.8	12.8	13.8	12.1	13.1	13.8	12.1	13.0	15.6	14.3	14.9	15.6	14.3	14.9	15.8	14.4	15.0
10/12/03	13.2	11.8	12.6	13.5	12.1	12.9	13.5	12.1	12.8	15.4	14.6	14.9	15.6	14.6	15.0	15.8	14.5	15.1
10/13/03	12.9	11.2	12.2	13.2	11.5	12.5	13.2	11.6	12.4	14.9	13.8	14.4	14.9	14.0	14.5	15.1	13.9	14.6
10/14/03	12.8	11.1	12.0	13.1	11.5	12.3	13.0	11.5	12.2	15.1	13.8	14.4	15.1	13.8	14.5	15.3	13.9	14.6
10/15/03	12.3	10.9	11.7	12.6	11.2	12.0	12.5	11.3	12.0	14.8	14.0	14.3	14.9	14.0	14.3	15.1	13.9	14.4
10/16/03	12.8	10.7	11.9	12.9	11.2	12.1	12.9	11.2	12.0	14.9	13.7	14.2	14.9	13.7	14.3	15.1	13.7	14.4
10/17/03	12.8	11.1	12.0	12.9	11.5	12.3	12.9	11.5	12.2	14.8	13.8	14.3	14.9	14.0	14.3	15.1	13.9	14.4
10/18/03	12.4	11.1	11.9	12.7	11.3	12.1	12.5	11.5	12.0	14.4	13.8	14.1	14.8	13.8	14.1	15.0	13.7	14.2
10/19/03	12.8	11.1	12.0	12.9	11.5	12.2	12.9	11.5	12.2	14.4	13.5	13.9	14.6	13.5	14.0	14.8	13.4	14.1
10/20/03	13.1	11.2	12.3	13.4	11.5	12.5	13.2	11.6	12.4	15.4	13.8	14.4	15.6	13.8	14.5	15.6	13.7	14.6
10/21/03	13.1	11.5	12.3	13.4	11.8	12.6	13.2	11.8	12.5	14.8	14.0	14.3	14.9	14.0	14.4	15.1	14.0	14.5
10/22/03	13.1	11.4	12.3	13.2	11.7	12.5	13.2	11.6	12.5	14.3	13.8	14.0	14.4	13.8	14.1	14.7	13.7	14.2
10/23/03	13.1	11.2	11.8	13.2	11.7	12.5	13.0	11.6	12.4	14.9	13.7	14.3	15.1	13.7	14.3	15.3	13.7	14.4
10/24/03	12.9	11.2	12.1	13.1	11.5	12.3	13.0	11.5	12.3	14.4	13.4	13.9	14.6	13.5	14.0	14.5	13.6	14.1
10/25/03	12.9	11.1	12.1	13.1	11.5	12.3	13.0	11.5	12.2	14.6	13.8	14.2	14.6	13.8	14.2	14.8	13.9	14.3
10/26/03	13.4	11.5	12.5	13.7	11.8	12.7	13.5	11.8	12.6	15.2	13.8	14.4	15.1	13.8	14.4	15.1	13.9	14.5
10/27/03	13.2	11.7	12.5	13.4	12.0	12.8	13.3	12.1	12.7	15.1	14.0	14.5	15.1	14.0	14.5	15.3	14.0	14.6
10/28/03	13.1	11.7	12.4	13.4	12.0	12.7	13.3	11.9	12.6	14.8	14.0	14.4	14.8	14.0	14.4	15.0	14.0	14.5
10/29/03	13.2	11.7	12.4	13.4	12.0	12.7	13.3	11.9	12.6	14.9	14.1	14.4	14.9	14.1	14.5	15.0	14.0	14.5
10/30/03	12.3	10.9	11.7	12.6	11.3	12.0	12.5	11.2	11.9	14.1	13.4	13.7	14.1	13.4	13.7	14.0	13.3	13.7
10/31/03	11.7	10.9	11.3	12.0	11.2	11.5	11.8	11.2	11.4	13.4	12.4	13.0	13.4	12.4	13.0	13.4	12.5	13.0

	Downstream from Goose Riffle Pool A5-1648.5			Downstream from Project Boundary Pool (3-3)			Near Gridley Pool (3-4)			Downstream from Junkyard Riffle Pool A5-1560.5			Upstream from Honcut Creek Pool (3-5)			At Singh AB Riviera Rd. Pool A5-1556.5		
Date	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean
04/01/03																		
04/02/03																		
04/03/03																		
04/04/03																		
04/05/03																		
04/06/03																		
04/07/03																		
04/08/03																		
04/09/03																		
04/10/03																		
04/11/03																		
04/12/03																		
04/13/03																		
04/14/03																		
04/15/03																		
04/16/03																		
04/17/03																		
04/18/03																16.5	15.0	15.7
04/19/03																16.8	15.4	16.0
04/20/03																16.5	15.5	16.1
04/21/03																15.5	14.4	15.1
04/22/03																15.8	14.1	14.8
04/23/03																15.8	14.9	15.4
04/24/03																14.9	14.1	14.6
04/25/03																13.9	13.2	13.5
04/26/03																14.4	12.7	13.5
04/27/03																15.8	14.1	14.9
04/28/03																15.2	13.9	14.7
04/29/03																13.9	13.3	13.6
04/30/03																15.4	13.3	14.3

	Downstream from Goose Riffle Pool A5-1648.5			Downstream from Project Boundary Pool (3-3)			Near Gridley Pool (3-4)			Downstream from Junkyard Riffle Pool A5-1560.5			Upstream from Honcut Creek Pool (3-5)			At Singh AB Riviera Rd. Pool A5-1556.5		
Date	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean
05/01/03																16.1	15.0	15.6
05/02/03																15.8	14.3	15.2
05/03/03																14.6	14.1	14.3
05/04/03																15.7	13.9	14.8
05/05/03																16.9	15.2	16.0
05/06/03																16.8	16.0	16.4
05/07/03																16.6	15.5	16.0
05/08/03																15.8	15.2	15.6
05/09/03																16.6	14.6	15.6
05/10/03																18.1	15.5	16.8
05/11/03																18.2	15.8	17.1
05/12/03																18.9	16.3	17.7
05/13/03																19.8	16.9	18.5
05/14/03																19.8	17.7	19.0
05/15/03																19.5	16.9	18.1
05/16/03				19.5	16.5	17.8										19.4	16.6	18.1
05/17/03				20.2	17.1	18.5										20.0	17.3	18.7
05/18/03				18.6	16.5	17.5										19.5	17.1	18.1
05/19/03				18.9	16.2	17.4										18.9	16.5	17.8
05/20/03				19.2	16.3	17.5										19.5	16.9	18.2
05/21/03				19.4	16.5	17.7										19.7	17.1	18.5
05/22/03				19.4	16.5	17.7										19.8	17.3	18.6
05/23/03				19.0	16.2	17.4										19.5	17.1	18.4
05/24/03				17.3	15.1	16.3										19.2	16.5	17.4
05/25/03				18.2	15.5	16.8										18.5	15.5	17.0
05/26/03				19.7	16.6	18.0										19.5	16.9	18.1
05/27/03				19.7	18.2	18.9										20.6	17.9	19.3
05/28/03				20.0	18.2	19.0										21.0	18.4	19.5
05/29/03				18.6	16.2	17.6										19.5	17.3	18.7
05/30/03				18.7	15.8	16.9										18.4	15.8	17.1
05/31/03				19.4	17.0	17.9										19.7	17.1	18.4

	Downstream from Goose Riffle Pool A5-1648.5			Downstream from Project Boundary Pool (3-3)			Near Gridley Pool (3-4)			Downstream from Junkyard Riffle Pool A5-1560.5			Upstream from Honcut Creek Pool (3-5)			At Singh AB Riviera Rd. Pool A5-1556.5		
Date	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean
06/01/03				21.0	17.4	19.1										21.0	17.6	19.2
06/02/03				21.1	18.1	19.5										21.0	18.7	20.0
06/03/03				20.3	18.2	19.2										21.0	19.0	20.1
06/04/03				19.8	17.0	18.4										20.3	18.1	19.2
06/05/03				19.7	17.3	18.3										20.3	17.9	19.1
06/06/03				19.4	16.8	18.1										20.0	17.6	18.7
06/07/03				19.7	17.0	18.4										20.3	17.7	18.9
06/08/03				20.3	17.4	18.7										20.5	18.1	19.3
06/09/03				20.2	18.1	18.9										20.8	18.4	19.5
06/10/03				20.0	17.4	18.6										20.2	17.7	19.0
06/11/03				20.3	18.1	19.0										20.6	18.1	19.4
06/12/03				19.8	17.7	18.6										20.2	17.7	19.0
06/13/03				20.0	17.4	18.7										20.3	17.7	19.0
06/14/03				20.7	17.6	18.9										20.5	18.2	19.4
06/15/03				21.0	17.9	19.3										21.0	18.5	19.9
06/16/03				21.3	18.7	19.8										21.6	19.2	20.6
06/17/03				21.5	18.7	19.8										21.8	19.4	20.7
06/18/03				20.3	17.7	19.1										21.5	19.2	20.1
06/19/03				20.8	17.4	19.0										20.6	18.5	19.7
06/20/03				21.3	17.7	19.4										21.0	18.7	19.9
06/21/03				21.8	17.9	19.8										21.3	19.0	20.2
06/22/03				21.8	19.0	20.2										21.6	19.7	20.8
06/23/03				22.1	19.0	20.5										21.6	19.8	20.9
06/24/03				22.5	19.7	20.9										22.1	20.3	21.3
06/25/03				23.1	19.8	21.4										23.0	20.5	21.8
06/26/03				22.8	20.7	21.7	23.0	20.7	21.8				23.5	21.0	22.1	23.5	21.1	22.3
06/27/03				21.6	20.0	20.9	21.9	20.1	21.0				22.2	20.5	21.3	22.1	20.6	21.5
06/28/03				20.5	19.0	19.6	20.7	18.9	19.6				21.0	19.0	19.9	21.1	19.4	20.2
06/29/03				19.5	17.7	18.7	19.4	17.8	18.7				19.7	17.9	18.9	19.7	18.1	19.0
06/30/03				19.5	17.9	18.7	19.6	18.0	18.7				19.9	18.1	18.9	20.0	18.4	19.1
07/01/03				18.7	17.1	18.0	18.8	17.2	18.0				19.0	17.3	18.2	19.2	17.4	18.4

	Downstream from Goose Riffle Pool A5-1648.5			Downstream from Project Boundary Pool (3-3)			Near Gridley Pool (3-4)			Downstream from Junkyard Riffle Pool A5-1560.5			Upstream from Honcut Creek Pool (3-5)			At Singh AB Riviera Rd. Pool A5-1556.5		
Date	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean
07/02/03				18.1	16.8	17.5	18.1	16.8	17.5				18.6	17.1	17.8	18.7	17.3	17.9
07/03/03				17.7	16.0	16.9	17.6	15.9	16.9				17.9	16.2	17.1	18.1	16.3	17.2
07/04/03	17.7	16.1	17.0	17.9	16.2	17.1	18.0	16.2	17.1				18.1	16.3	17.2	18.2	16.5	17.3
07/05/03	18.1	16.3	17.2	18.2	16.3	17.3	18.3	16.4	17.3				18.6	16.5	17.5	18.5	16.6	17.6
07/06/03	18.2	16.5	17.3	18.2	16.6	17.4	18.4	16.5	17.4				18.6	16.6	17.6	18.5	16.8	17.7
07/07/03	17.9	16.5	17.1	17.9	16.5	17.3	18.0	16.5	17.3				18.2	16.6	17.4	18.2	16.6	17.5
07/08/03	18.2	16.5	17.3	18.4	16.6	17.4	18.4	16.5	17.4				18.6	16.5	17.5	18.5	16.6	17.6
07/09/03	18.4	16.6	17.5	18.6	16.8	17.6	18.6	16.8	17.7				18.6	16.8	17.8			
07/10/03	18.9	16.9	17.9	18.9	17.1	18.0	19.1	17.0	18.0	19.2	17.1	18.1	19.0	17.1	18.1			
07/11/03	19.4	17.4	18.3	19.5	17.6	18.5	19.4	17.5	18.5	19.6	17.6	18.6	19.5	17.6	18.6			
07/12/03	18.9	17.6	18.3	19.0	17.7	18.4	19.1	17.8	18.5	19.4	17.9	18.7	19.4	17.9	18.6			
07/13/03	19.0	16.8	17.9	19.0	17.0	18.0	19.1	17.0	18.0	19.2	17.1	18.2	19.0	17.1	18.2			
07/14/03	18.4	17.1	17.7	18.6	17.3	17.9	18.6	17.2	17.9	18.9	17.3	18.1	18.9	17.3	18.1			
07/15/03	18.4	16.8	17.7	18.4	17.0	17.8	18.6	17.0	17.8	18.9	17.1	18.0	18.9	17.1	17.9			
07/16/03	19.4	16.9	18.1	19.4	17.1	18.2	19.4	17.0	18.2	19.6	17.1	18.4	19.5	17.1	18.3			
07/17/03	19.5	17.7	18.6	19.7	17.9	18.7	19.6	17.8	18.7	19.7	17.9	18.9	19.7	17.9	18.9			
07/18/03	19.2	17.9	18.5	19.4	18.1	18.6	19.6	18.0	18.7	19.7	18.1	18.9	19.7	18.1	18.9			
07/19/03	18.4	17.6	18.0	18.6	17.7	18.1	18.6	17.6	18.2	18.9	17.8	18.4	19.0	17.8	18.4			
07/20/03	19.0	17.7	18.2	19.0	17.9	18.3	19.1	17.8	18.3	19.1	17.9	18.5	19.0	17.8	18.5			
07/21/03	18.9	17.3	18.0	19.0	17.4	18.1	19.1	17.5	18.2	19.2	17.6	18.4	19.0	17.6	18.4			
07/22/03	18.7	16.9	17.8	18.9	17.1	17.9	18.9	17.2	18.0	19.1	17.3	18.2	19.0	17.3	18.1			
07/23/03	18.7	17.3	18.0	18.9	17.3	18.1	18.9	17.3	18.2	19.2	17.5	18.3	19.2	17.4	18.3			
07/24/03	19.5	18.1	18.6	19.7	18.1	18.7	19.7	18.1	18.7	19.9	18.1	18.9	18.9	18.1	18.8			
07/25/03	18.7	17.7	18.3	18.7	17.9	18.4	18.9	17.8	18.4	19.4	17.9	18.7	19.2	17.9	18.6	19.4	18.1	18.8
07/26/03	19.2	17.4	18.3	19.4	17.6	18.5	19.4	17.6	18.5	19.7	17.8	18.7	19.5	17.6	18.6	19.7	17.7	18.7
07/27/03	19.2	18.1	18.6	19.4	18.2	18.7	19.4	18.1	18.7	19.7	18.1	18.9	19.7	18.1	18.9	19.8	18.2	19.0
07/28/03	19.2	17.6	18.4	19.2	17.7	18.5	19.3	17.8	18.5	19.4	17.9	18.7	19.4	17.9	18.7	19.4	18.2	18.8
07/29/03	18.7	17.4	18.0	18.9	17.4	18.2	18.8	17.5	18.2	19.1	17.8	18.5	19.0	17.8	18.5	19.2	17.9	18.6
07/30/03	18.4	17.1	17.8	18.6	17.3	17.9	18.4	17.2	17.9	18.8	17.3	18.1	18.7	17.3	18.1	19.0	17.4	18.2
07/31/03	18.7	17.3	17.9	18.7	17.4	18.1	18.9	17.3	18.1	19.2	17.5	18.2	19.0	17.4	18.2	19.2	17.4	18.3
08/01/03	18.7	17.7	18.1	18.7	17.9	18.3	18.8	17.8	18.3	18.9	17.8	18.4	18.9	17.8	18.4	19.0	17.9	18.5

	Downstream from Goose Riffle Pool A5-1648.5			Downstream from Project Boundary Pool (3-3)			Near Gridley Pool (3-4)			Downstream from Junkyard Riffle Pool A5-1560.5			Upstream from Honcut Creek Pool (3-5)			At Singh AB Riviera Rd. Pool A5-1556.5		
Date	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean
08/02/03	18.2	16.8	17.3	18.2	17.0	17.4	18.1	17.0	17.4	18.4	17.1	17.6	18.4	17.1	17.6	18.4	17.3	17.7
08/03/03	18.2	16.3	17.2	18.2	16.5	17.4	18.3	16.5	17.4	18.4	16.8	17.6	18.4	16.8	17.5	18.4	17.1	17.6
08/04/03	18.2	16.5	17.4	18.2	16.6	17.5	18.3	16.7	17.5	18.6	16.8	17.7	18.6	16.8	17.7	18.7	16.9	17.8
08/05/03	18.4	16.8	17.5	18.4	16.8	17.7	18.4	16.8	17.7	18.8	17.0	17.9	18.7	17.0	17.8	18.7	17.1	17.9
08/06/03	18.5	17.1	17.9	18.6	17.3	18.0	18.8	17.3	18.0	19.1	17.5	18.2	19.0	17.4	18.1	19.0	17.6	18.2
08/07/03	18.9	17.3	18.1	19.0	17.4	18.2	19.3	17.3	18.2	19.4	17.5	18.4	19.4	17.4	18.3	19.5	17.6	18.5
08/08/03	20.0	17.4	18.6	20.2	17.6	18.7	20.1	17.6	18.7	20.2	17.8	18.9	20.0	17.8	18.8	20.0	17.9	18.9
08/09/03	20.0	17.9	18.9	20.0	18.1	19.1	20.2	18.1	19.1	20.5	18.3	19.3	20.5	18.2	19.3	20.5	18.4	19.4
08/10/03	20.3	18.1	19.1	20.5	18.2	19.3	20.5	18.3	19.3	20.9	18.4	19.5	20.7	18.4	19.5	20.6	18.4	19.6
08/11/03	20.3	18.1	19.2	20.5	18.2	19.3	20.5	18.3	19.4	20.9	18.4	19.6	20.7	18.4	19.6	20.6	18.5	19.7
08/12/03	20.3	18.5	19.3	20.5	18.7	19.4	20.7	18.6	19.5	20.9	18.6	19.7	20.8	18.6	19.6	20.8	18.7	19.8
08/13/03	19.8	17.7	18.8	20.0	17.9	19.0	20.2	18.0	19.0	20.4	17.9	19.2	20.3	18.1	19.1	20.3	18.1	19.2
08/14/03	19.5	18.2	18.7	19.7	18.4	18.9	19.9	18.3	18.9	20.2	18.4	19.2	20.2	18.4	19.2	20.3	18.4	19.3
08/15/03	19.5	17.6	18.4	19.5	17.7	18.6	19.7	17.6	18.6	20.1	17.8	18.8	20.0	17.8	18.7	20.0	17.9	18.9
08/16/03	19.5	17.3	18.4	19.5	17.4	18.5	19.7	17.3	18.5	20.1	17.5	18.7	20.0	17.4	18.7	20.0	17.6	18.8
08/17/03	18.5	17.1	17.8	18.7	17.1	17.9	18.9	17.2	18.0	19.2	17.3	18.3	19.2	17.3	18.3	19.4	17.4	18.4
08/18/03	18.4	16.9	17.5	18.6	17.1	17.7	18.8	17.0	17.8	19.1	17.1	18.0	19.0	17.1	18.0	19.0	17.3	18.1
08/19/03	17.9	16.5	17.1	18.1	16.6	17.2	18.1	16.7	17.3	18.4	16.8	17.6	18.4	16.8	17.5	18.5	16.9	17.7
08/20/03	17.7	16.3	17.0	17.7	16.5	17.2	17.8	16.5	17.2	18.3	16.7	17.4	18.2	16.6	17.3	18.4	16.6	17.5
08/21/03	17.1	16.1	16.7	17.3	16.3	16.8	17.3	16.5	16.9	17.5	16.7	17.1	17.4	16.6	17.1	17.6	16.8	17.2
08/22/03	16.3	15.7	16.0	16.5	15.8	16.1	16.7	15.9	16.2	16.8	16.0	16.4	16.8	16.0	16.4	16.9	16.1	16.5
08/23/03	17.3	15.4	16.2	17.4	15.5	16.3	17.5	15.4	16.3	17.5	15.6	16.4	17.4	15.5	16.4	17.6	15.5	16.5
08/24/03	17.7	16.1	16.9	17.9	16.3	17.1	18.0	16.2	17.1	18.1	16.4	17.2	18.1	16.3	17.2	18.2	16.5	17.3
08/25/03	18.2	16.6	17.4	18.4	16.8	17.6	18.4	16.7	17.6	18.6	16.8	17.7	18.6	16.8	17.7	18.7	16.9	17.8
08/26/03	18.4	16.9	17.6	18.6	17.1	17.7	18.6	17.2	17.8	18.9	17.3	18.0	18.9	17.3	17.9	18.9	17.4	18.1
08/27/03	18.4	16.9	17.7	18.6	17.1	17.8	18.8	17.2	17.9	19.1	17.3	18.0	19.0	17.3	18.0	19.0	17.4	18.1
08/28/03	18.5	17.3	17.9	18.7	17.3	18.0	18.9	17.3	18.0	19.2	17.5	18.2	19.2	17.4	18.2	19.4	17.6	18.3
08/29/03	18.9	17.1	17.9	19.0	17.3	18.0	19.3	17.2	18.1	19.4	17.3	18.2	19.4	17.3	18.2	19.4	17.4	18.3
08/30/03	18.9	16.9	17.8	19.0	17.1	17.9	18.9	17.2	18.0	19.2	17.3	18.2	19.0	17.3	18.1	19.2	17.4	18.3
08/31/03	18.4	17.1	17.8	18.6	17.4	17.9	18.9	17.3	17.9	19.2	17.3	18.1	19.2	17.3	18.1	19.4	17.4	18.1
09/01/03	18.4	16.8	17.4	18.4	17.0	17.6	18.4	16.8	17.6	18.9	17.0	17.9	18.9	17.0	17.9	19.0	16.9	18.0

	Downstream from Goose Riffle Pool A5-1648.5			Downstream from Project Boundary Pool (3-3)			Near Gridley Pool (3-4)			Downstream from Junkyard Riffle Pool A5-1560.5			Upstream from Honcut Creek Pool (3-5)			At Singh AB Riviera Rd. Pool A5-1556.5		
Date	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean
09/02/03	18.9	16.6	17.5	19.0	16.8	17.7	19.1	16.7	17.7	19.2	16.8	17.9	19.2	16.8	17.9	19.2	16.9	18.0
09/03/03	17.6	16.1	16.7	17.7	16.3	16.9	17.6	16.4	17.0	18.1	16.7	17.2	18.1	16.6	17.2	18.4	16.8	17.4
09/04/03	17.1	15.7	16.3	17.3	15.8	16.4	17.3	15.9	16.5	17.5	16.0	16.7	17.4	16.0	16.7	17.6	16.1	16.8
09/05/03	17.3	15.4	16.2	17.4	15.5	16.4	17.6	15.4	16.4	17.9	15.6	16.6	17.8	15.5	16.5	17.9	15.7	16.7
09/06/03	16.9	15.4	16.0	17.1	15.5	16.2	17.3	15.4	16.3	17.5	15.6	16.5	17.4	15.5	16.4	17.6	15.7	16.6
09/07/03	16.6	15.5	16.0	16.8	15.5	16.1	16.8	15.6	16.1	17.0	15.7	16.3	17.0	15.5	16.2	17.1	15.7	16.3
09/08/03	16.5	15.0	15.6	16.6	15.2	15.8	16.7	15.3	15.9	17.0	15.4	16.0	16.8	15.4	15.9	16.9	15.4	16.1
09/09/03	15.2	14.1	14.8	15.4	14.3	14.9	15.6	14.3	15.1	15.9	14.6	15.3	15.8	14.6	15.3	16.0	14.9	15.5
09/10/03	15.5	13.9	14.7	15.7	14.1	14.8	15.9	14.0	14.9	16.2	14.1	15.0	16.2	14.0	15.0	16.1	14.1	15.1
09/11/03	16.0	14.3	15.0	16.0	14.4	15.2	16.2	14.5	15.2	16.5	14.6	15.4	16.5	14.6	15.4	16.6	14.6	15.5
09/12/03	16.5	14.6	15.4	16.6	14.7	15.5	16.8	14.6	15.6	17.1	14.8	15.8	17.1	14.7	15.8	17.3	14.7	15.9
09/13/03	16.6	14.9	15.6	16.8	14.9	15.8	17.0	14.8	15.8	17.3	14.9	16.0	17.1	14.9	15.9	17.3	14.9	16.1
09/14/03	17.3	15.0	16.0	17.4	15.2	16.1	17.5	15.3	16.2	17.6	15.2	16.4	17.4	15.2	16.3	17.4	15.4	16.4
09/15/03	16.8	15.0	15.9	17.0	15.2	16.0	17.0	15.4	16.1	17.3	15.6	16.4	17.3	15.5	16.4	17.3	15.8	16.6
09/16/03	17.1	15.4	16.2	17.3	15.5	16.3	17.5	15.4	16.3	17.6	15.6	16.4	17.4	15.5	16.4	17.4	15.5	16.5
09/17/03	17.4	15.7	16.4	17.6	15.8	16.5	17.8	15.7	16.5	17.9	15.7	16.7	17.8	15.7	16.6			
09/18/03	17.3	15.4	16.3	17.4	15.4	16.4	17.5	15.4	16.4	17.6	15.4	16.5	17.6	15.4	16.5			
09/19/03	17.7	15.5	16.5	17.9	15.7	16.7	18.0	15.7	16.7	17.9	15.9	16.9						
09/20/03	18.1	15.8	16.9	18.2	15.8	17.0	18.3	15.7	17.0	18.4	15.9	17.2						
09/21/03	18.4	16.3	17.2	18.6	16.5	17.3	18.4	16.4	17.4	18.6	16.5	17.6						
09/22/03	18.7	16.5	17.5	18.9	16.6	17.7	18.9	16.5	17.7	19.1	16.7	17.9						
09/23/03	18.4	16.3	17.3	18.6	16.5	17.5	18.8	16.4	17.6	18.9	16.7	17.8						
09/24/03	18.1	16.0	16.8	18.4	16.2	17.0	18.4	16.2	17.2	18.4	16.5	17.6						
09/25/03	17.9	15.8	16.6	18.1	16.0	16.7	18.1	15.9	16.8	18.1	15.9	17.0						
09/26/03	17.9	16.0	16.7	18.1	16.0	16.9	18.1	16.0	16.9	18.1	16.2	17.2						
09/27/03	17.7	16.1	16.9	17.9	16.3	17.0	18.1	16.2	17.1	18.1	16.4	17.3						
09/28/03	17.9	16.1	16.9	18.1	16.3	17.1	18.1	16.2	17.1	18.3	16.4	17.4						
09/29/03	17.6	15.8	16.7	17.9	15.8	16.8	18.0	15.9	16.8	17.9	16.2	17.1						
09/30/03	18.2	16.3	17.1	18.4	16.3	17.3	18.4	16.2	17.3	18.4	16.4	17.4						
10/01/03	17.7	16.0	16.8	18.1	16.2	17.0	18.1	16.2	17.0	17.9	16.5	17.3						
10/02/03	17.9	15.8	16.7	18.1	16.0	16.8	18.1	15.9	16.9	17.9	16.0	17.1						

	Downstream from Goose Riffle Pool A5-1648.5			Downstream from Project Boundary Pool (3-3)			Near Gridley Pool (3-4)			Downstream from Junkyard Riffle Pool A5-1560.5			Upstream from Honcut Creek Pool (3-5)			At Singh AB Riviera Rd. Pool A5-1556.5		
Date	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean
10/03/03	17.4	15.8	16.5	17.6	16.0	16.6	17.8	15.9	16.7	17.8	16.0	16.9						
10/04/03	17.4	15.8	16.6	17.7	16.0	16.7	17.8	15.9	16.7	17.8	16.2	16.9	17.6	16.3	17.0	17.6	16.3	17.0
10/05/03	18.2	16.3	17.2	18.4	16.5	17.3	18.3	16.4	17.3	18.3	16.5	17.4	18.1	16.5	17.4	18.1	16.5	17.4
10/06/03	18.2	16.3	17.2	18.4	16.5	17.4	18.4	16.5	17.4	18.4	16.7	17.6	18.4	16.9	17.8	18.4	16.9	17.8
10/07/03	18.1	16.1	17.1	18.2	16.3	17.3	18.1	16.5	17.3	18.1	16.7	17.5	18.1	16.9	17.7	18.1	16.9	17.7
10/08/03	17.9	16.0	16.8	18.1	16.2	17.0	18.1	16.0	17.0	18.1	16.4	17.3	17.9	16.6	17.4	17.9	16.6	17.4
10/09/03	17.6	15.7	16.5	17.7	15.8	16.6	17.6	15.9	16.6	17.5	16.0	16.8	17.6	16.1	16.9	17.6	16.1	16.9
10/10/03	16.3	14.9	15.5	16.5	15.1	15.7	16.5	15.1	15.7	16.7	15.2	15.9	16.9	15.4	16.1	16.9	15.4	16.1
10/11/03	16.1	14.3	15.1	16.3	14.4	15.3	16.4	14.3	15.2	16.4	14.3	15.4	16.1	14.6	15.4	16.1	14.6	15.4
10/12/03	16.3	14.4	15.2	16.5	14.6	15.3	16.5	14.5	15.4	16.4	14.6	15.5	16.1	14.7	15.6	16.1	14.7	15.6
10/13/03	15.5	13.9	14.7	15.8	14.0	14.8	15.9	14.0	14.9	15.7	14.1	15.0	15.7	14.4	15.1	15.7	14.4	15.1
10/14/03	15.7	13.9	14.7	15.8	14.0	14.8	15.9	14.0	14.8	15.7	14.0	14.9	15.5	14.1	15.0	15.5	14.1	15.0
10/15/03	15.5	13.8	14.5	15.7	14.0	14.7	15.6	13.8	14.7	15.6	14.0	14.8	15.4	14.1	14.9	15.4	14.1	14.9
10/16/03	15.5	13.6	14.5	15.8	13.8	14.7	15.7	13.7	14.7	15.7	14.0	14.8	15.7	13.9	14.9	15.5	13.9	14.8
10/17/03	15.5	13.8	14.6	15.7	14.0	14.7	15.7	13.8	14.7	15.6	14.0	14.9	15.7	14.1	15.0	15.5	14.1	15.0
10/18/03	15.4	13.8	14.4	15.5	13.8	14.5	15.4	13.7	14.5	15.4	13.8	14.7	15.5	14.1	14.8	15.4	14.1	14.8
10/19/03	15.2	13.5	14.2	15.4	13.7	14.4	15.4	13.5	14.4	15.4	13.8	14.6	15.4	13.9	14.7	15.2	13.9	14.7
10/20/03	15.8	13.8	14.7	16.2	13.8	14.8	16.0	13.7	14.8	16.0	13.8	14.8	16.0	13.9	14.9	15.8	13.9	14.9
10/21/03	15.7	13.9	14.7	16.0	14.1	14.8	15.9	14.0	14.9	15.9	14.1	15.1	16.0	14.4	15.3	15.8	14.4	15.2
10/22/03	15.2	13.8	14.4	15.4	14.0	14.5	15.4	13.8	14.6	15.6	14.0	14.8	15.7	14.2	15.0	15.7	14.3	14.9
10/23/03	15.7	13.6	14.5	15.8	13.8	14.6	15.7	13.8	14.6	15.6	13.8	14.7	15.5	14.1	14.8	15.4	13.9	14.8
10/24/03	15.0	13.6	14.3	15.2	13.7	14.4	15.3	13.8	14.5	15.2	14.0	14.7	15.5	14.2	14.8	15.4	14.1	14.8
10/25/03	15.4	13.8	14.4	15.7	13.8	14.6	15.7	13.7	14.5	15.7	13.7	14.6	15.7	13.8	14.7	15.5	13.6	14.7
10/26/03	15.4	13.8	14.5	15.7	14.0	14.7	15.6	13.8	14.7	15.6	14.0	14.8	15.7	14.1	14.9	15.5	14.1	14.9
10/27/03	15.7	13.9	14.7	15.8	14.1	14.9	15.7	14.2	14.9	15.7	14.3	15.0	15.8	14.4	15.1	15.5	14.4	15.1
10/28/03	15.5	13.9	14.6	15.7	14.1	14.7	15.6	14.2	14.8	15.6	14.1	14.9	15.7	14.4	15.1	15.5	14.4	15.0
10/29/03	15.5	14.1	14.6	15.7	14.1	14.8	15.6	14.2	14.8	15.6	14.3	14.9	15.5	14.4	15.0	15.4	14.3	14.9
10/30/03	14.4	13.3	13.8	14.6	13.5	13.9	14.6	13.5	14.0	14.6	13.5	14.1	15.0	13.8	14.2	14.9	13.6	14.1
10/31/03	13.5	12.6	13.1	13.7	12.7	13.2	13.5	12.8	13.3	13.5	12.7	13.3	13.9	13.0	13.4	13.8	12.9	13.3

State of California
The Resources Agency
Department of Water Resources

FINAL REPORT
EVALUATION OF OROVILLE FACILITIES OPERATIONS ON WATER TEMPERATURE-RELATED EFFECTS ON PRE-SPAWNING ADULT CHINOOK SALMON AND CHARACTERIZATION OF HOLDING HABITAT
SP-F10, TASKS 1D AND 1E

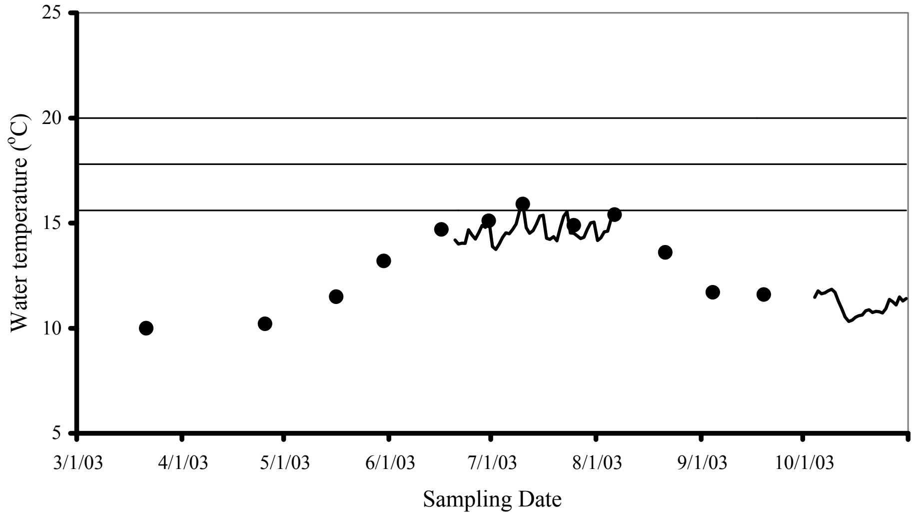
APPENDIX C
MEAN WATER COLUMN TEMPERATURE DATA AND MEAN DAILY THERMOGRAPH DATA COLLECTED IN FEATHER RIVER POOLS
(MARCH 2003 THROUGH OCTOBER 2003)

Oroville Facilities Relicensing
FERC Project No. 2100

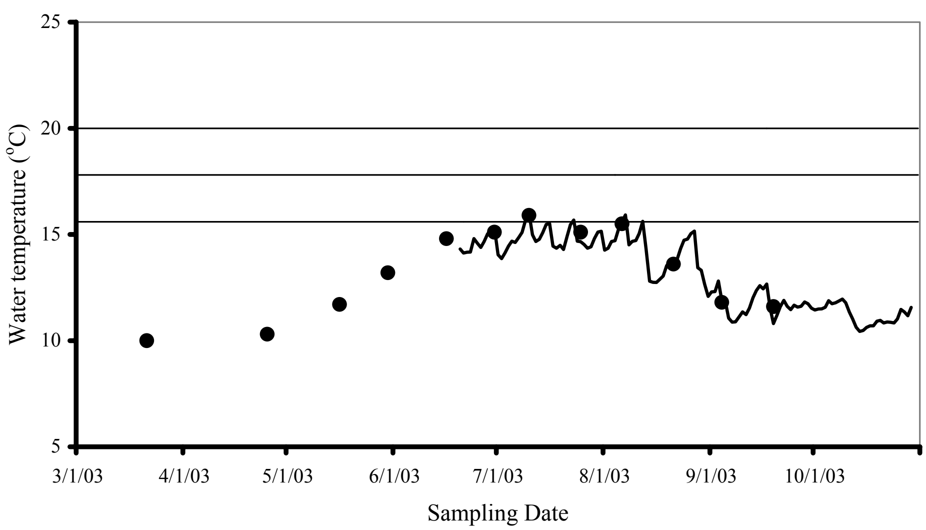
JUNE 2004

The following graphs represent available mean water column and daily mean water temperatures recorded during the 2003 spring-run Chinook salmon immigration and holding period. Mean water column temperatures collected using methods described in Section 4.2.1.1 are represented by black dots on each graph. Daily mean water temperatures recorded by stationary thermographs as described in Section 4.2.1.2 are represented by thick black lines. Thin horizontal black lines indicate each of the three water temperature index values described in Section 4.1.9.2.

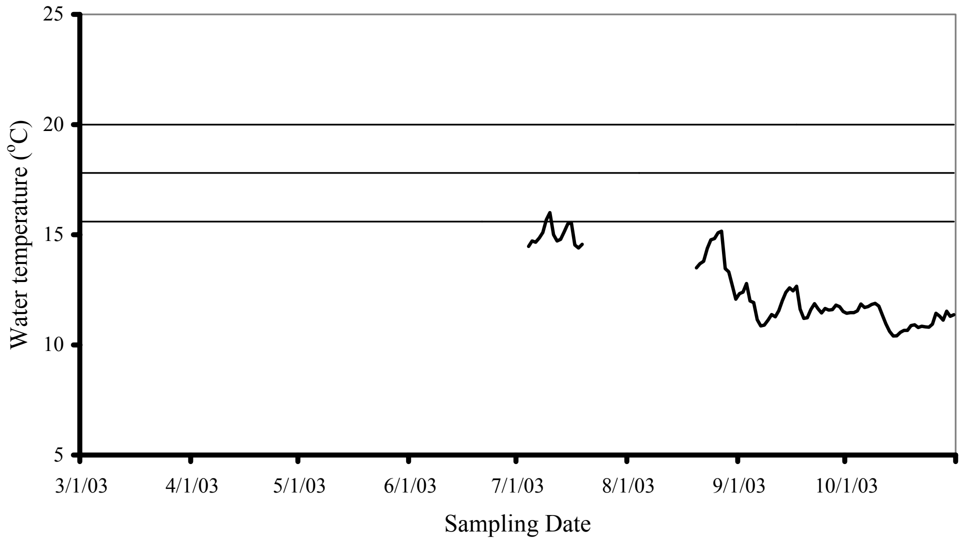
Feather River Downstream from Fish Barrier Dam
N 39º 31' 8.5" W 121º 32' 53"
Pool A5-1797.50 (1-1)



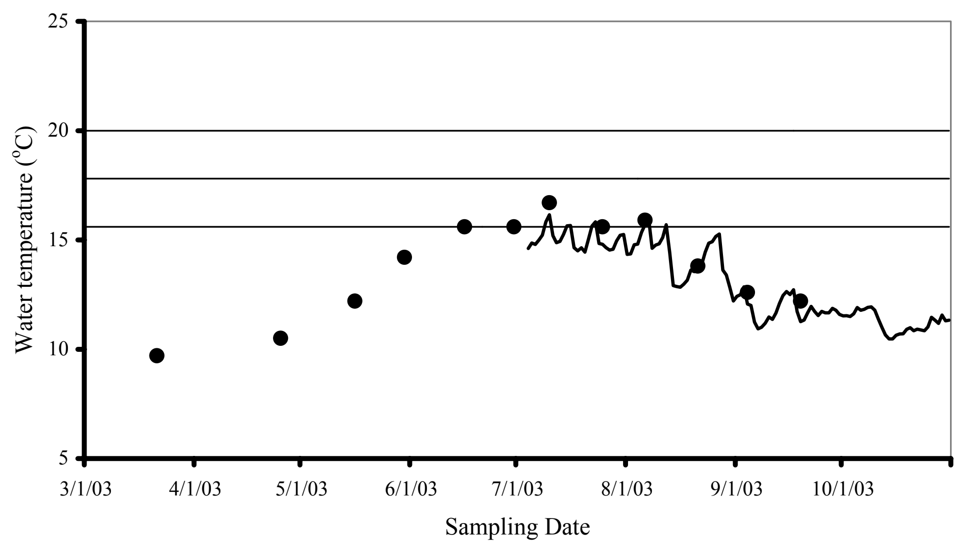
Feather River Upstream from Hatchery
N 39º 31' 3.5" W 121º 33' 1.2"
Pool A5-1789.50 (1-2)



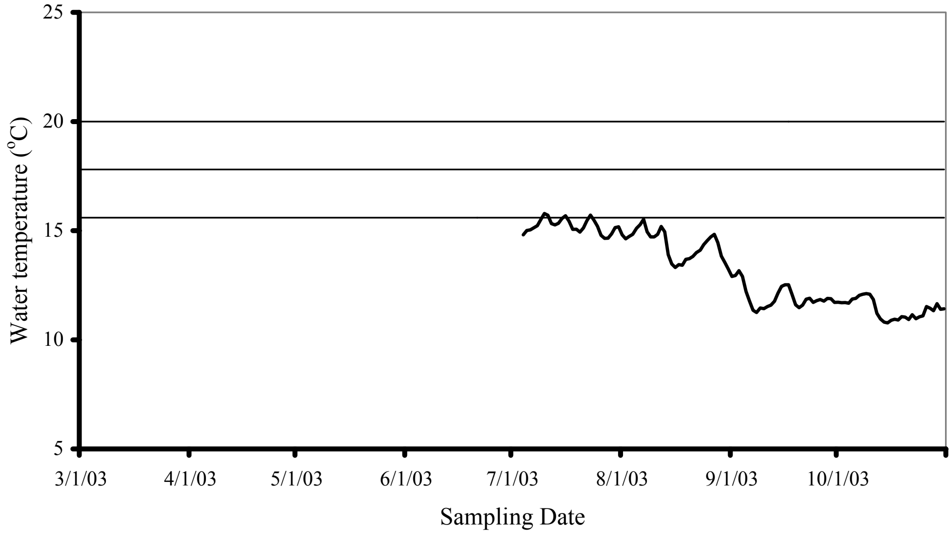
Feather River Upstream from Auditorium Riffle
N 39º 30' 58.7" W 121º 33' 20.4"
Pool A5-1783.50



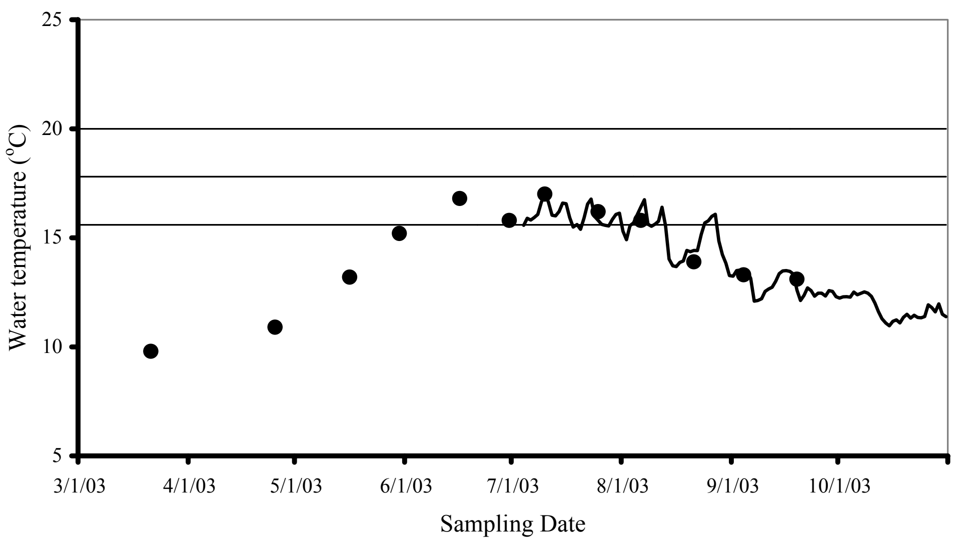
Feather River Downstream from Hatchery
N 39º 30' 55.1" W 121º 33' 44.7"
Pool A5-1778.50 (1-3)



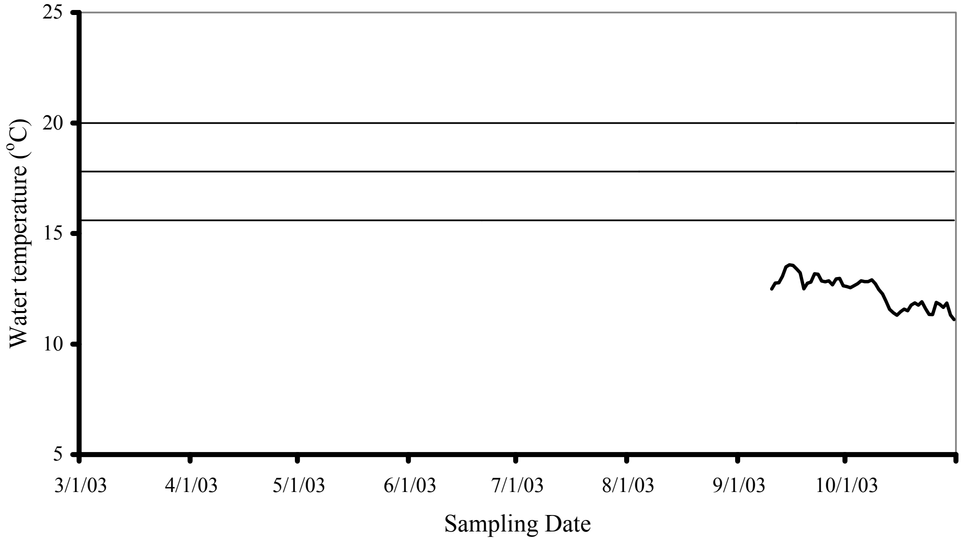
Feather River At Highway 70
N 39° 30' 43.5" W 121° 34' 21.6"
Pool A5-1776.50



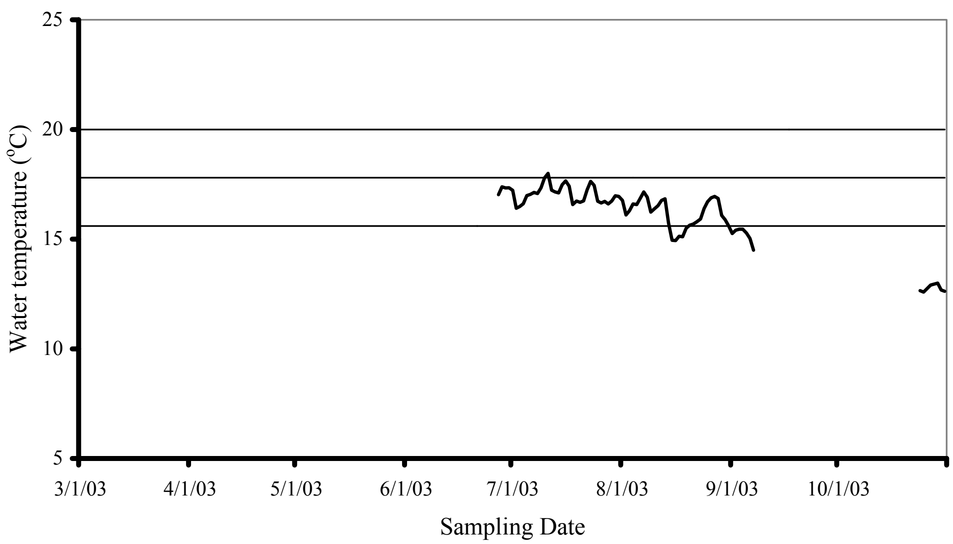
Feather River Upstream from Hwy 162 Bridge
N 39° 29' 53.3" W 121° 34' 45.4"
Pool A5-1741.50 (1-4)



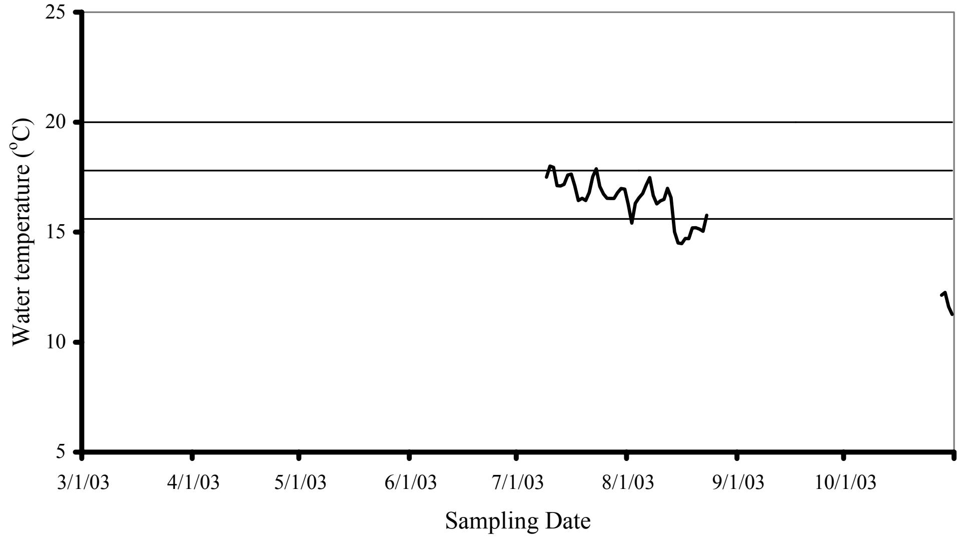
Feather River Downstream from Matthews Riffle
N 39° 29' 16.1" W 121° 34' 39.8"
Pool A5-1738.50



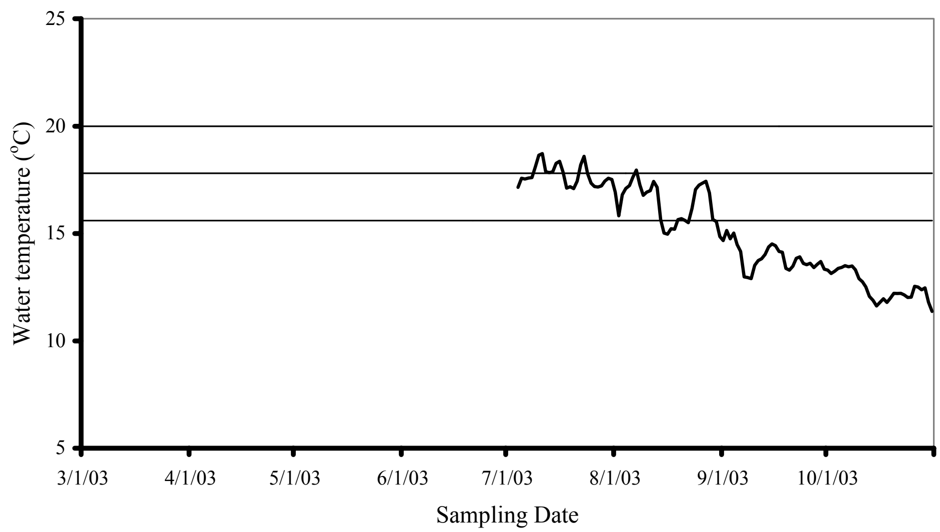
Feather River Upstream from Great Western
N 39º 28' 34.2" W 121º 34' 47.8"
Pool A5-1725.50



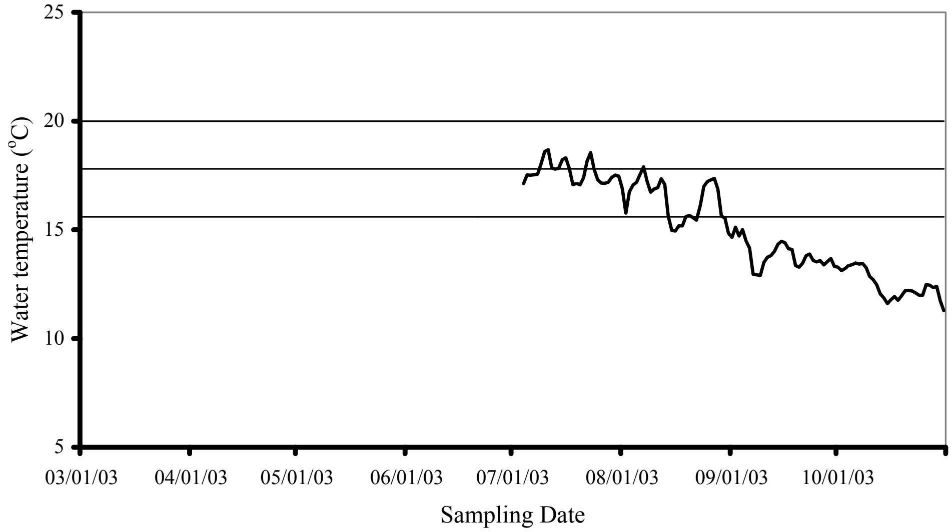
Feather River At Granite
N 39º 28' 10.4" W 121º 35' 6.9"
Pool A5-1715.50



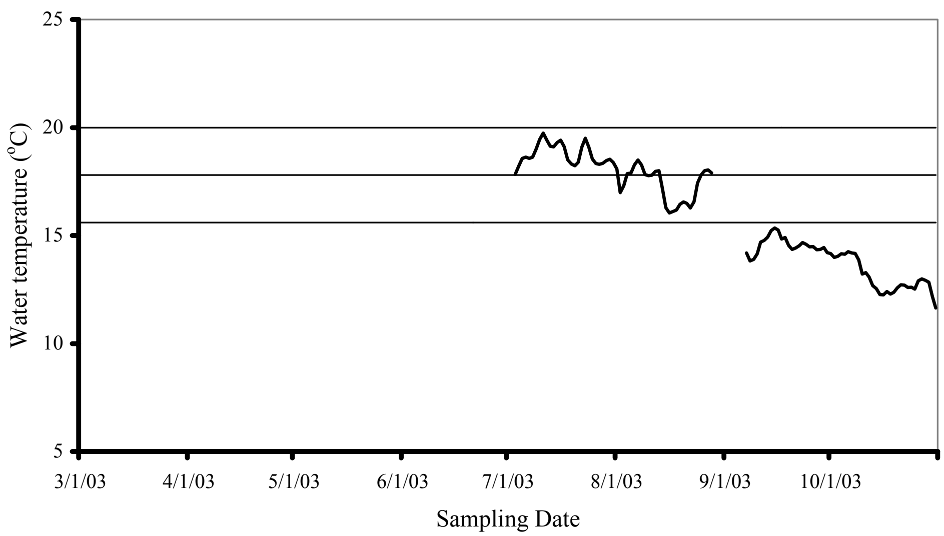
Feather River At Flask
N 39º 28' 1.7" W 121º 35' 48.8"
Pool A5-1711.50



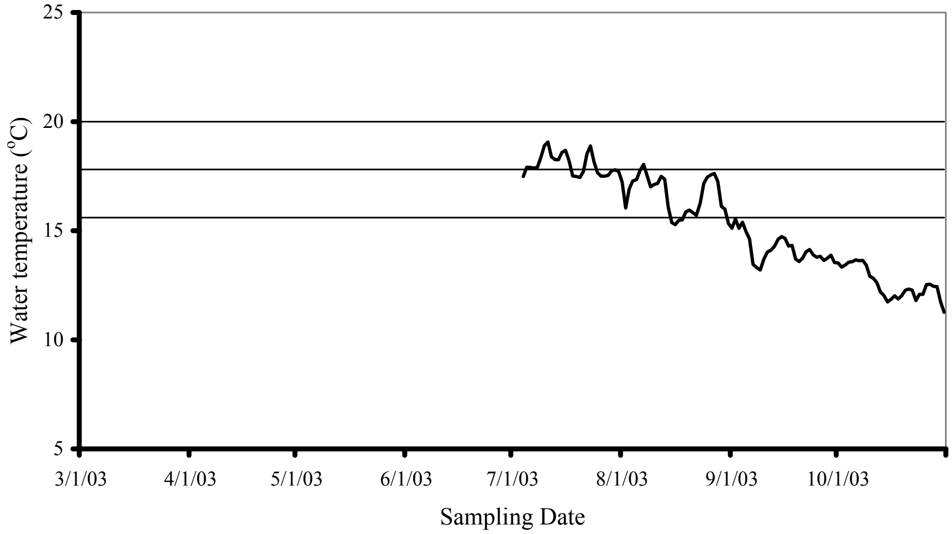
Feather River Upstream from Steep Riffle
N 39º 27' 55.1" W 121º 36' 8.3"
Pool A5-1710.50



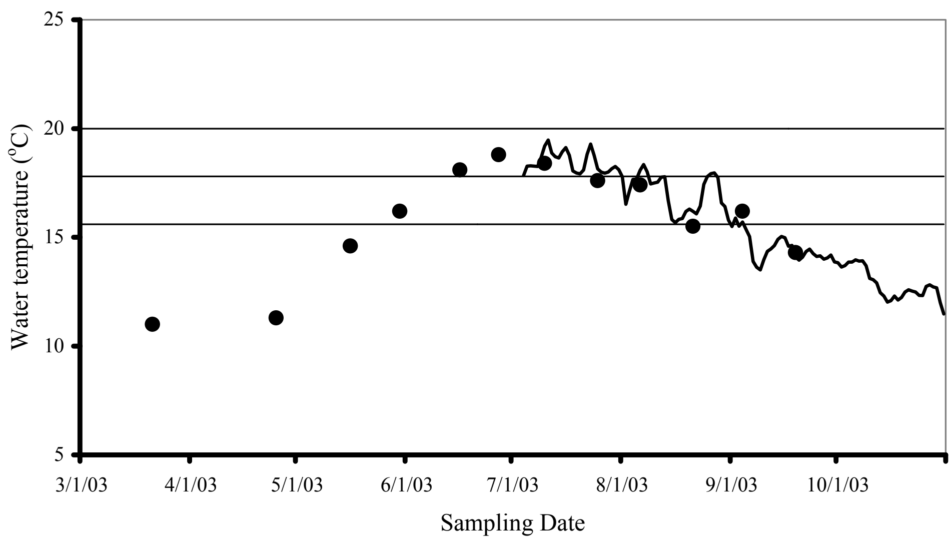
Feather River Downstream from Steep Riffle
N 39º 27' 42.5" W 121º 36' 16.2"
Pool A5-1709.50

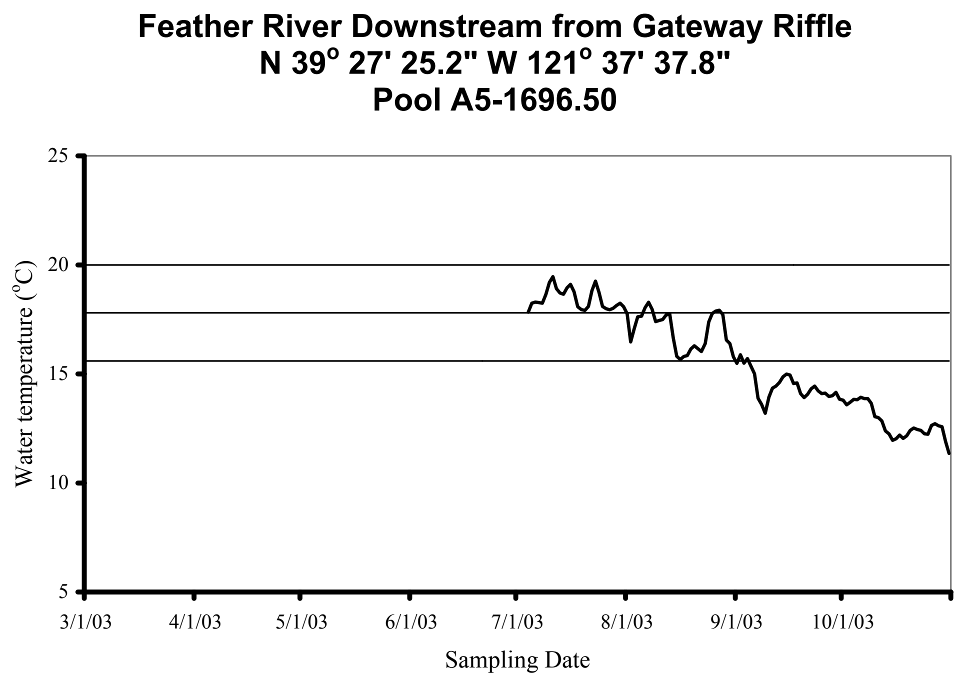


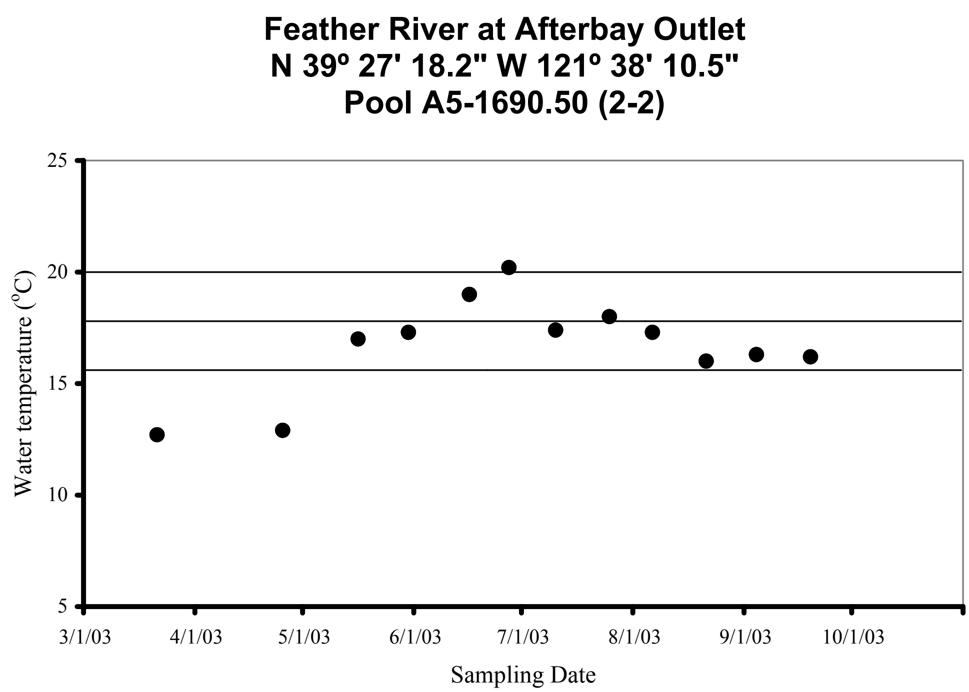
Feather River Upstream from Eye Riffle
N 39º 27' 39.5" W 121º 36' 33.1"
Pool A5-1708.50



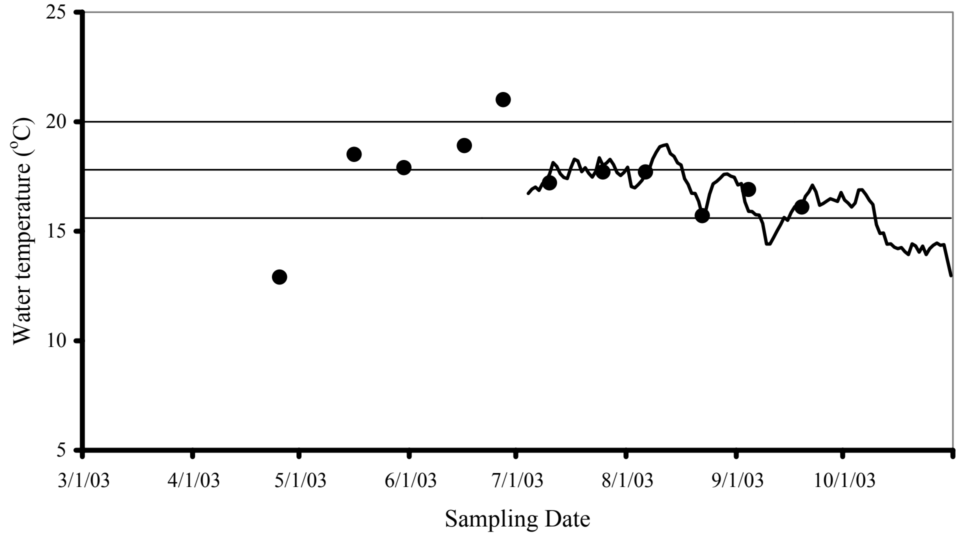
Feather River Upstream Afterbay Outlet
N 39º 27' 23.4" W 121º 37' 13.5"
Pool A5-1698.50 (2-1)



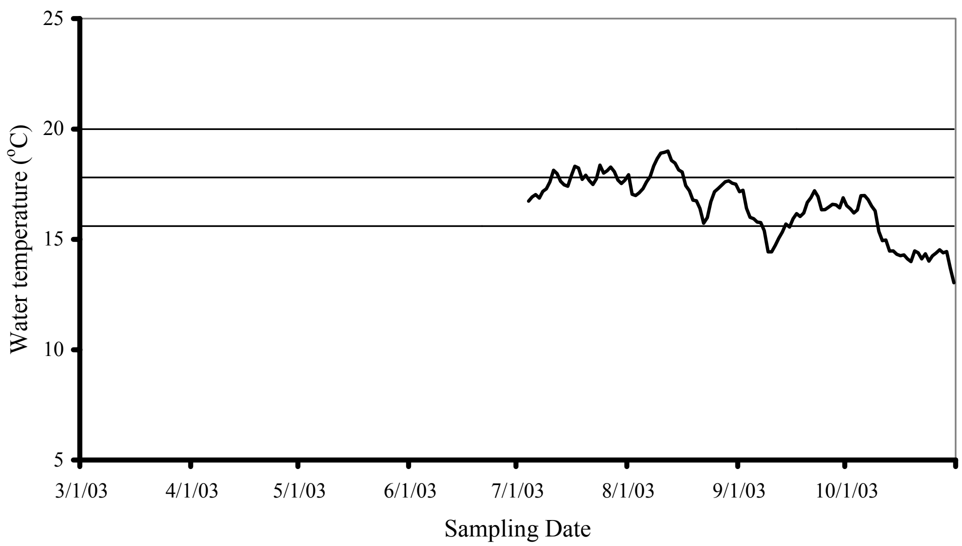

Feather River Downstream from Gateway Riffle
N 39° 27' 25.2" W 121° 37' 37.8"
Pool A5-1696.50
25
20
15
10
5
Water temperature (°C)
3/1/03
4/1/03
5/1/03
6/1/03
7/1/03
8/1/03
9/1/03
10/1/03
Sampling Date


Feather River at Afterbay Outlet
N 39° 27' 18.2" W 121° 38' 10.5"
Pool A5-1690.50 (2-2)
25
20
15
10
5
Water temperature (°C)
3/1/03
4/1/03
5/1/03
6/1/03
7/1/03
8/1/03
9/1/03
10/1/03
Sampling Date

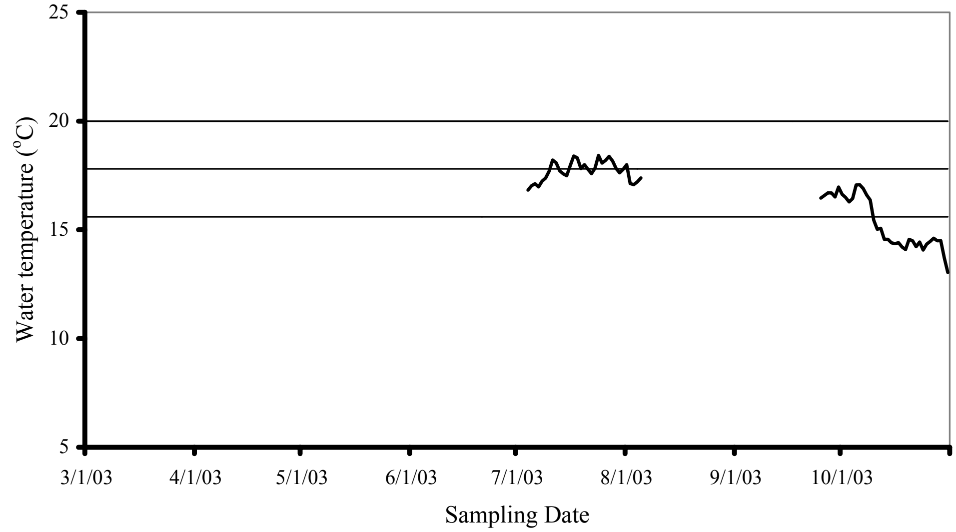
Feather River Downstream from Afterbay Outlet
N 39º 26' 48.8" W 121º 38' 15.7"
Pool A5-1686.50 (3-1)



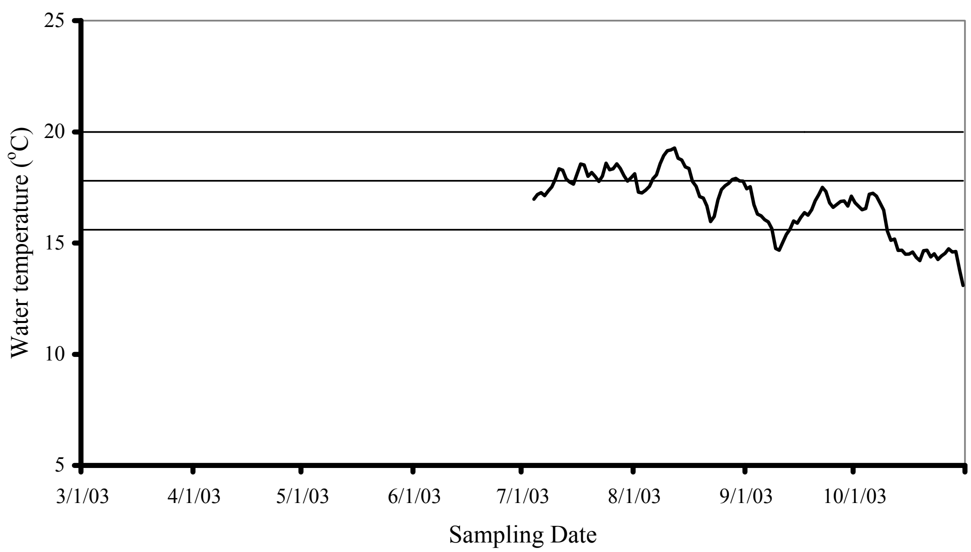
Feather River Island Left Channel
N 39° 26' 5.9" W 121° 38' 9.7"
Pool A5-1665.50



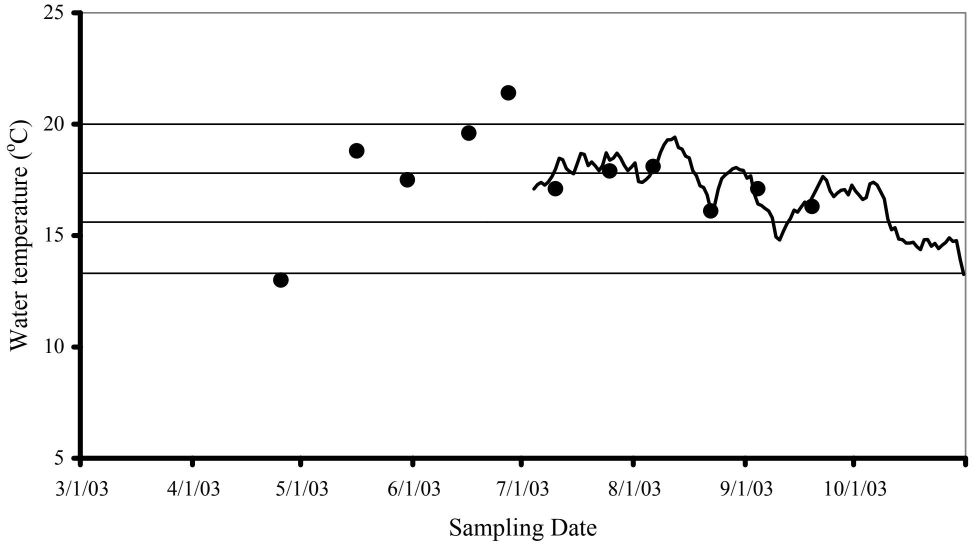
Feather River Upstream from Keester Riffle
N 39° 25' 17.2" W 121° 37' 34.8"
Pool A5-1656.50



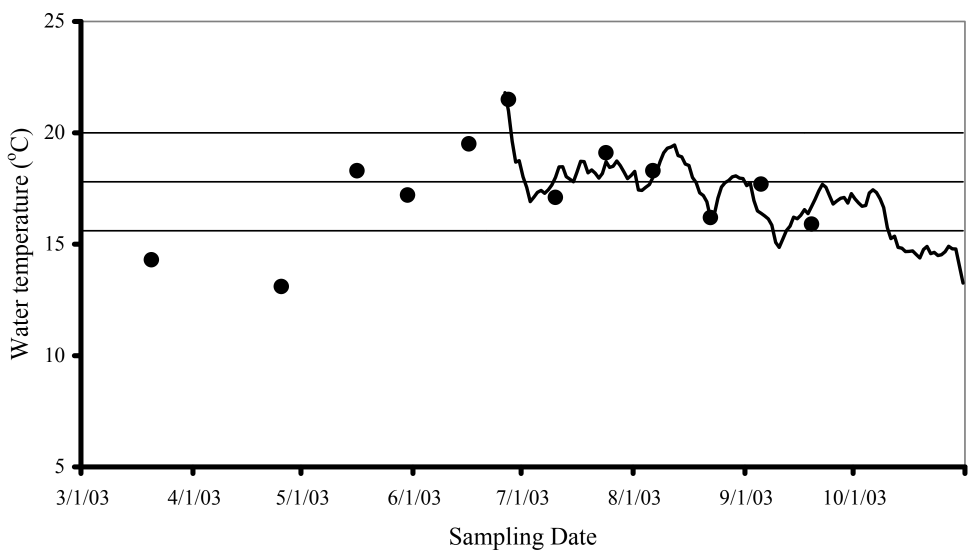
Feather River Downstream from Goose Riffle
N 39° 23' 49.2" W 121° 37' 11.9
Pool A5-1648.50



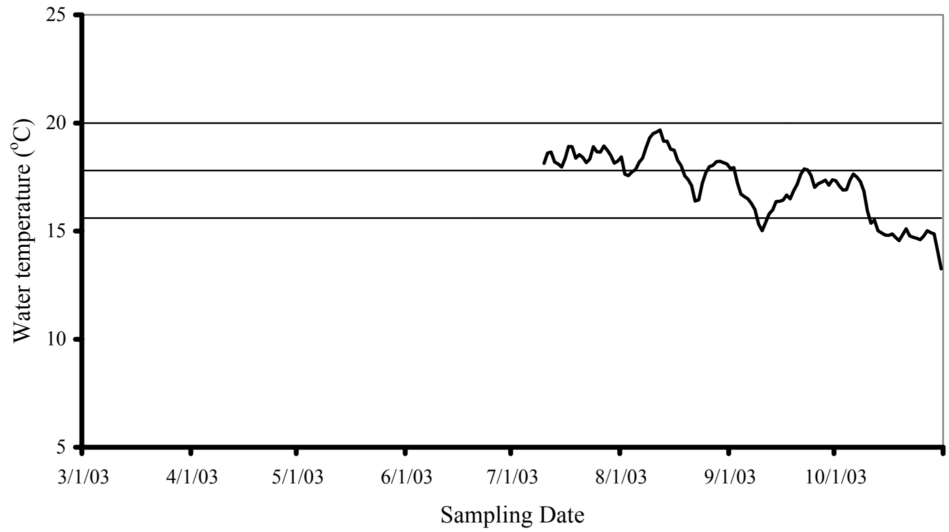
Feather River Downstream from Project Boundary
N 39º 23' 18.6" W 121º 37' 29.7"
Pool A5-1646.50 (3-3)



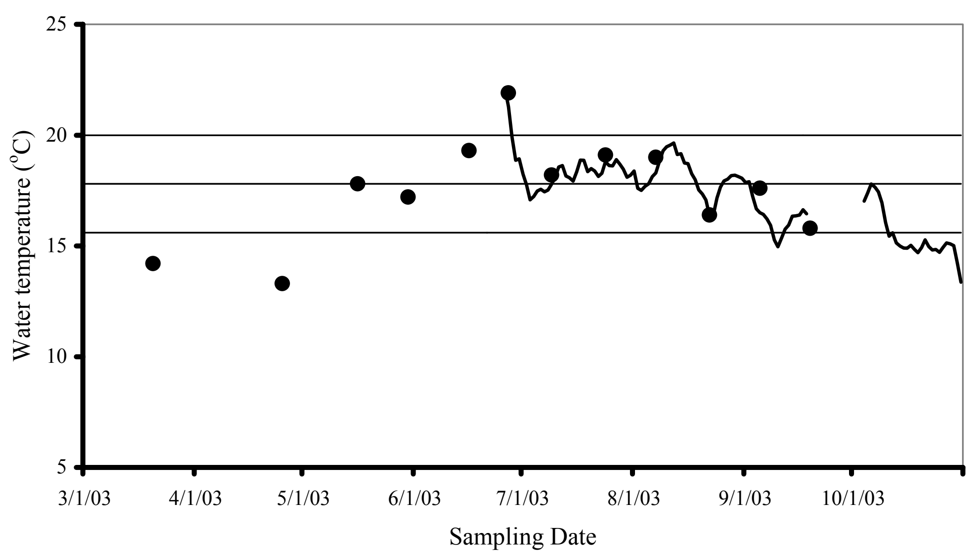
Feather River Near Gridley
N 39º 21' 59.6" W 121º 38' 50.3"
Pool A5-1613.50 (3-4)



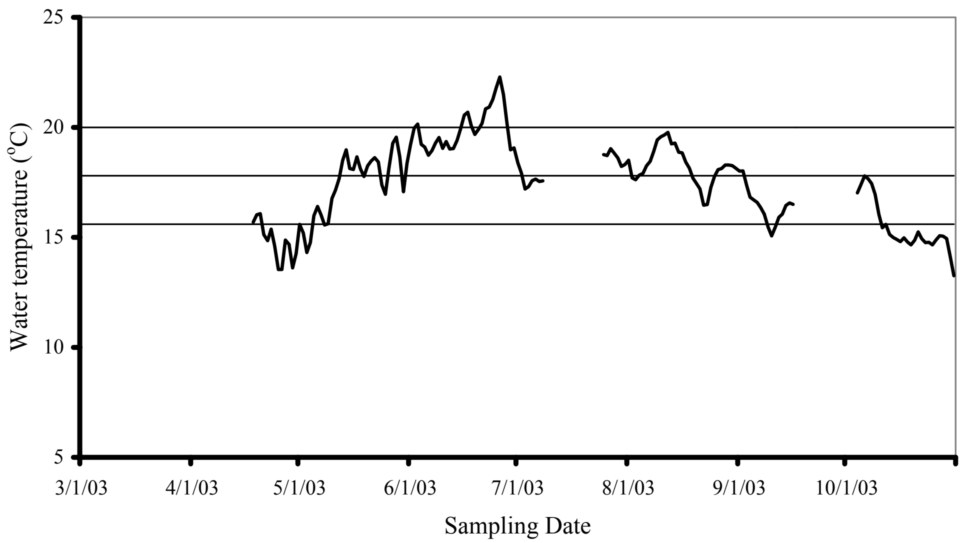
Feather River Downstream from Junkyard Riffle
N 39° 20' 17.2" W 121° 37' 51.6"
Pool (A5-1560.50)



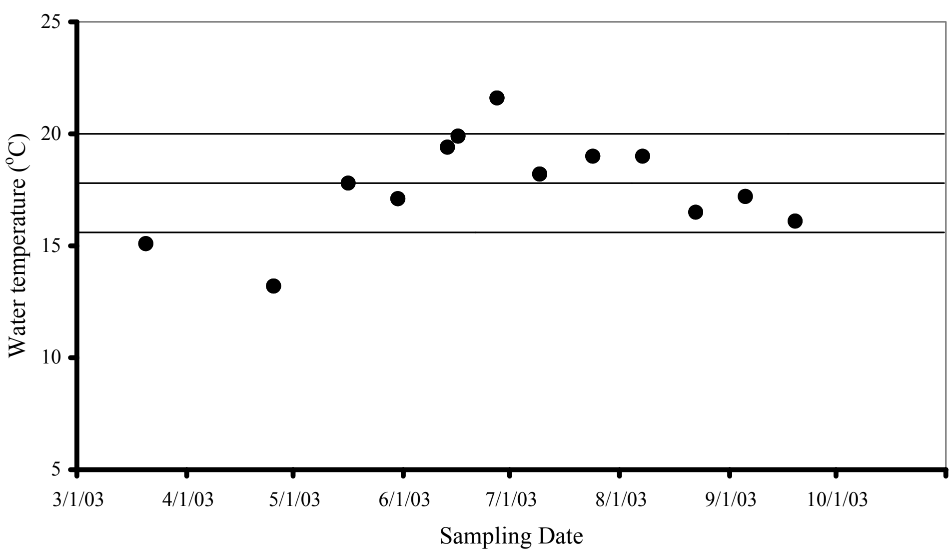
Feather River Upstream from Honcut Creek
N 39º 19' 39.4" W 121º 37' 31.8"
Pool A5-1558.50 (3-5)



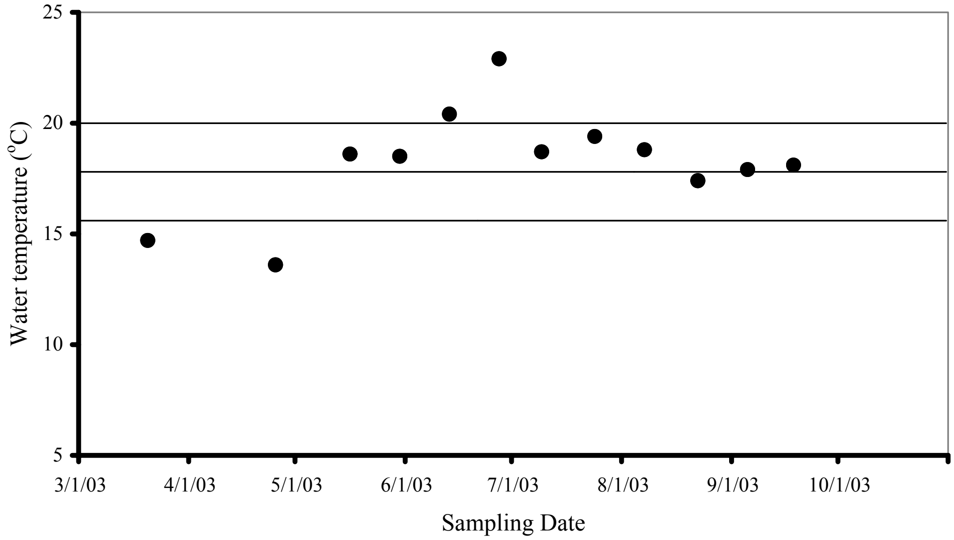
Feather River At Singh AB Riviera Rd.
N 39° 18' 40.4" W 121° 37' 39.3"
Pool A5-1556.50



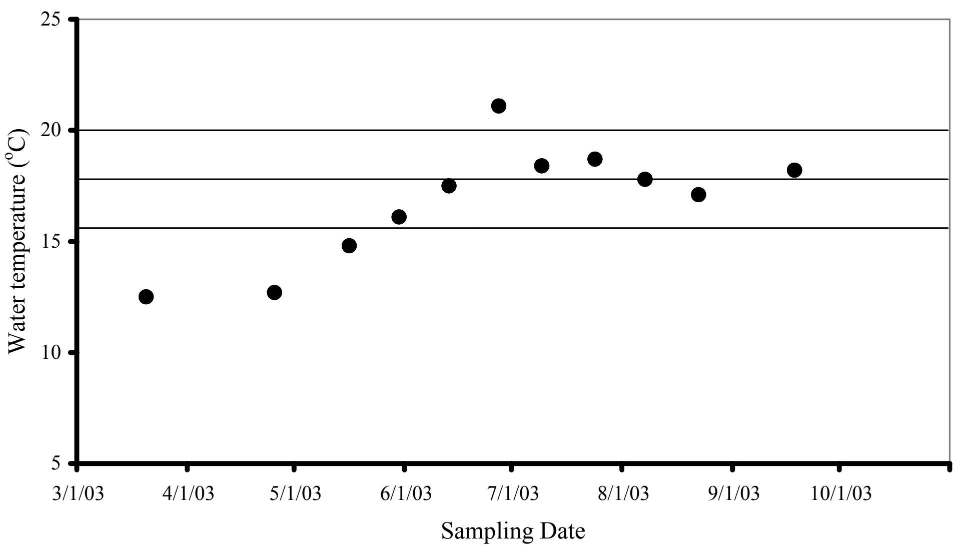
Feather River at Archer Ave.
N 39º 16' 21.4" W 121º 37' 55.0"
Pool A5-1517.50 (4-1)



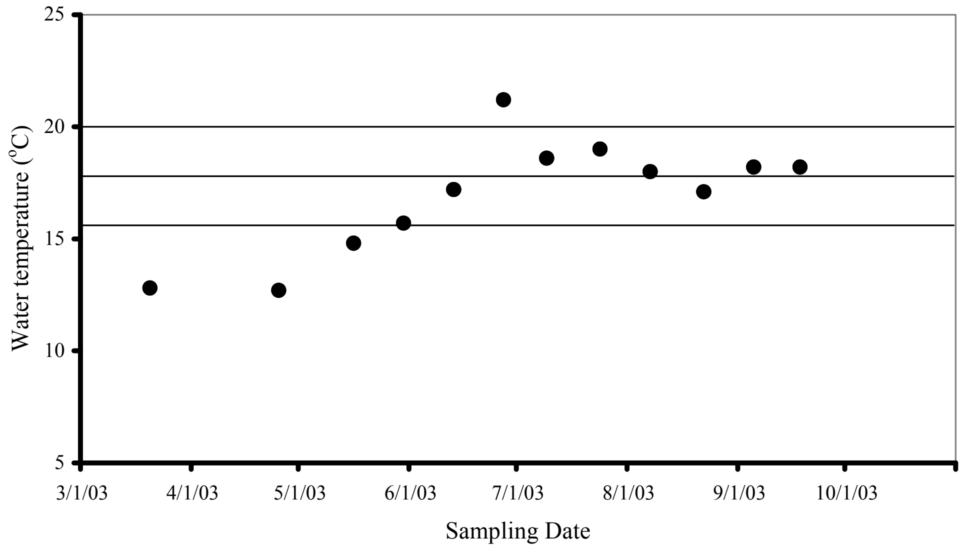
Feather River Upstream from Confluence with Yuba River
N 39º 7' 50.3" W 121º 35' 57.8"
Pool A5-1423.50 (4-2)



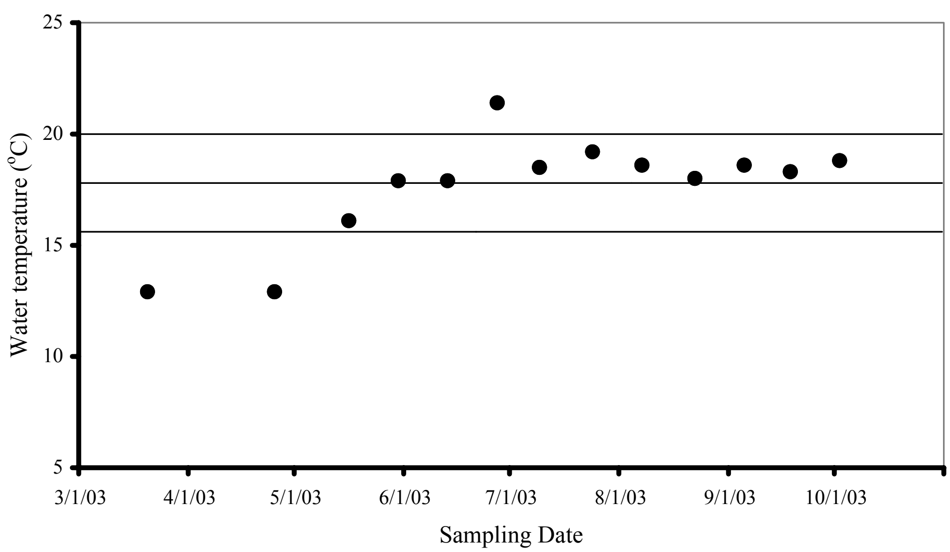
Feather River Near Shanghai Bend
N 39º 5' 22.4" W 121º 35' 59.1"
Pool A5-1387.50 (4-3)



Feather River at Star Bend
N 39º 0' 42.0" W 121º 35' 57.3"
Pool A5-1267.50 (4-4)



Feather River Near Verona
N 38º 47" 34.4" W 121º 37' 46.1"
Pool A5-1020.50 (4-5)



State of California
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FINAL REPORT
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SP-F10, TASKS 1D AND 1E

APPENDIX D
WATER COLUMN TEMPERATURE, DISSOLVED OXYGEN CONCENTRATION, AND DEPTH DATA COLLECTED IN FEATHER RIVER POOLS
(APRIL 2002 THROUGH OCTOBER 2002)

Oroville Facilities Relicensing
FERC Project No. 2100

JUNE 2004

Pool 1-1
Downstream from Fish Barrier Dam

April

Date: 4/30/2002 **Time:** 1200 P.S.T.		
Depth (m)	**Temp. (C)**	**D.O. (mg/l)**
0.0	10.4	11.6
0.5	10.4	11.7
1.0	10.4	11.7
1.5	10.4	11.7
2.0	10.4	11.7
2.5	10.4	11.7
3.0	10.4	11.7
3.5	10.4	11.7
4.0	10.4	11.7
Mean	10.4	11.7

May

Date: 5/16/2002 **Time:** 0740 P.S.T.			**Date:** 5/30/2002 **Time:** N/A		
Depth (m)	**Temp. (C)**	**D.O. (mg/l)**	**Depth (m)**	**Temp. (C)**	**D.O. (mg/l)**
0.0	10.8	N/A	0.0	13.4	10.4
0.5	10.8	11.0 (W)	0.5	13.4	10.5 (W)
1.0	10.7	N/A	1.0	13.4	10.3
1.5	10.7	N/A	1.5	13.4	10.3
2.0	10.7	N/A	2.0	13.4	10.3
2.5	10.7	N/A	2.5	13.4	10.3
3.0	10.7	N/A	3.0	13.4	10.3
3.5	10.7	N/A	3.5	13.4	10.2
Mean	10.7	N/A	Mean	13.4	10.3

June

Date: 6/12/2002 **Time:** 0915 PST			**Date:** 6/27/2002 **Time:** 0830 PST		
Depth (m)	**Temp. (C)**	**D.O. (mg/l)**	**Depth (m)**	**Temp. (C)**	**D.O. (mg/l)**
0.0	12.0	10.4	0.0	13.6	10.2
0.5	12.0	10.4	0.5	13.6	10.2
1.0	12.0	10.4	1.0	13.6	10.2
1.5	12.0	10.4	1.5	13.6	10.2
2.0	12.0	10.4	2.0	13.6	10.2
2.5	11.9	10.4	2.5	13.6	10.2
3.0	11.9	10.4	3.0	13.6	10.2
3.5	11.9	10.4	3.5	13.6	10.2
4.0	11.9	10.4	4.0	13.6	10.2
4.5	11.9	10.4	4.5	13.6	10.1
5.0	11.9	10.4	5.0	13.6	10.1
5.5	11.9	10.4			
6.0	11.9	10.4			
Mean	11.9	10.4	Mean	13.6	10.2

July

Date: 7/15/2002 **Time:** 0830 PST			**Date:** 7/25/2002 **Time:** 0755 PST		
Depth (m)	**Temp. (C)**	**D.O. (mg/l)**	**Depth (m)**	**Temp. (C)**	**D.O. (mg/l)**
0.0	12.4	9.6	0.0	12.4	9.6
0.5	12.4	9.6	0.5	12.4	9.6
1.0	12.4	9.7	1.0	12.4	9.7
1.5	12.4	9.6	1.5	12.4	9.6
2.0	12.4	9.6	2.0	12.4	9.6
2.5	12.4	9.5	2.5	12.4	9.5
3.0	12.4	9.5	3.0	12.4	9.5
3.5	12.4	9.5	3.5	12.4	9.5
4.0	12.4	9.5	4.0	12.4	9.5
4.5	12.4	9.4	4.5	12.4	9.4
5.0	12.4	9.4	5.0	12.4	9.4
5.5	12.4	9.4	5.5	12.4	9.4
6.0	12.4	9.3	6.0	12.4	9.3
6.5	12.4	9.3			
7.0	12.4	9.4			
Mean	12.4	9.5	Mean	12.4	9.5

August

Date: 8/22/2002 **Time:** 1555 PST			**Date:** 8/26/2002 **Time:** 1530 PST		
Depth (m)	**Temp. (C)**	**D.O. (mg/l)**	**Depth (m)**	**Temp. (C)**	**D.O. (mg/l)**
0.0	16.4	9.1	0.0	13.8	10.4
0.5	16.4	9.2	0.5	13.8	10.4
1.0	16.4	9.2	1.0	13.7	10.4
1.5	16.3	9.2	1.5	13.7	10.4
2.0	16.3	9.2	2.0	13.7	10.3
2.5	16.3	9.2	2.5	13.7	10.4
3.0	16.3	9.2	3.0	13.7	10.4
3.5	16.3	9.2	3.5	13.7	10.4
4.0	16.3	9.2	4.0	13.7	10.4
4.5	16.2	9.2	4.5	13.7	10.3
5.0	16.3	9.2	5.0	13.7	10.4
5.5	16.3	9.2	5.5	13.7	10.4
6.0	16.3	9.2	6.0	13.7	10.4
6.5	16.2	9.2	6.5	13.7	10.3
7.0	16.2	9.2	7.0	13.7	10.3
			7.5	13.7	10.3
Mean	16.3	9.2	Mean	13.7	10.4

September

Date: 9/5/2002 **Time:** 1605 PST			**Date:** 9/27/2002 **Time:** 0855 PST		
Depth (m)	**Temp. (C)**	**D.O. (mg/l)**	**Depth (m)**	**Temp. (C)**	**D.O. (mg/l)**
0.0	12.4	10.8	0.0	11.7	10.1
0.5	12.4	10.9	0.5	11.7	10.2
1.0	12.4	10.9	1.0	11.7	10.3
1.5	12.4	10.9	1.5	11.7	10.3
2.0	12.3	11.0	2.0	11.7	10.3
2.5	12.3	11.0	2.5	11.7	10.2
3.0	12.3	11.0	3.0	11.7	10.2
3.5	12.3	11.0	3.5	11.7	10.2
4.0	12.3	10.9	4.0	11.7	10.1
4.5	12.3	10.9	4.5	11.7	10.1
5.0	12.2	10.8	5.0	11.6	10.2
5.5	12.2	10.9	5.5	11.6	10.2
6.0	12.2	10.8	6.0	11.6	10.1
6.5	12.1	10.8	6.5	11.6	10.1
7.0	12.1	10.8			
Mean	12.3	10.9	Mean	11.7	10.2

October

Date: 10/9/2002 **Time:** 0830 PST			**Date:** 10/25/2002 **Time:** 0915 PST		
Depth (m)	**Temp. (C)**	**D.O. (mg/l)**	**Depth (m)**	**Temp. (C)**	**D.O. (mg/l)**
0.0	13.0	10.1	0.0	13.5	9.9
0.5	12.9	10.0	0.5	13.4	9.8
1.0	12.9	10.1	1.0	13.4	9.8
1.5	12.9	10.1	1.5	13.4	9.8
2.0	12.9	10.1	2.0	13.4	9.8
2.5	12.9	10.1	2.5	13.4	9.9
3.0	12.9	10.1	3.0	13.4	9.8
3.5	12.9	10.1	3.5	13.4	9.7
4.0	12.9	10.2	4.0	13.4	9.7
4.5	12.9	10.1	4.5	13.4	9.7
5.0	12.9	10.1	5.0	13.4	9.6
5.5	12.9	10.0	5.5	13.4	9.6
6.0	12.9	10.0	6.0	13.4	9.7
6.5	12.9	9.8	6.5	13.4	9.7
			7.0	13.4	9.5
Mean	12.9	10.1	Mean	13.4	9.7

Pool 1-2
Upstream from Hatchery Pool

April

Date: 4/30/2002 **Time:** 1230 P.S.T.		
Depth (m)	**Temp. (C)**	**D.O. (mg/l)**
0.0	11.2	11.5
0.5	11.0	11.5
1.0	10.9	11.4
1.5	10.7	11.5
2.0	10.7	11.7
2.5	10.6	11.8
3.0	10.6	11.8
3.5	10.6	11.8
4.0	10.6	11.7
4.5	10.5	11.6
5.0	10.5	11.7
Mean	10.7	11.6

May

Date: 5/16/2002 **Time:** 0800 PST			**Date:** 5/30/2002 **Time:** N/A		
Depth (m)	**Temp. (C)**	**D.O. (mg/l)**	**Depth (m)**	**Temp. (C)**	**D.O. (mg/l)**
0.0	10.8	N/A	0.0	13.4	10.3
0.5	10.8	11.0 (W)	0.5	13.3	10.3 (w)
1.0	10.8	N/A	1.0	13.3	10.3
1.5	10.8	N/A	1.5	13.4	10.3
2.0	10.8	N/A	2.0	13.4	10.3
2.5	10.8	N/A	2.5	13.3	10.3
3.0	10.8	N/A	3.0	13.3	10.3
3.5	10.8	N/A	3.5	13.3	10.3
4.0	10.8	N/A	4.0	13.3	10.2
4.5	10.8	N/A			
5.0	10.8	N/A			
Mean	10.8	N/A	Mean	13.3	10.3

June

Date: 6/12/2002 **Time:** 0930 PST			**Date:** 6/27/2002 **Time:** 0850 PST		
Depth (m)	**Temp. (C)**	**D.O. (mg/l)**	**Depth (m)**	**Temp. (C)**	**D.O. (mg/l)**
0.0	12.5	10.4	0.0	13.8	10.0
0.5	12.3	10.4	0.5	13.8	10.1
1.0	12.2	10.3	1.0	13.8	10.1
1.5	12.2	10.3	1.5	13.7	10.0
2.0	12.1	10.0	2.0	13.7	10.1
2.5	12.1	10.1	2.5	13.7	10.1
3.0	12.1	10.1	3.0	13.7	10.2
3.5	12.1	10.3	3.5	13.7	10.2
4.0	12.1	10.3	4.0	13.7	10.2
4.5	12.1	10.3	4.5	13.7	10.2
5.0	12.0	10.3	5.0	13.6	10.1
			5.5	13.6	10.2
			6.0	13.6	10.1
			6.5	13.6	10.1
Mean	12.2	10.3	Mean	13.7	10.1

July

Date: 7/15/2002 **Time:** 0840 PST			**Date:** 7/25/2002 **Time:** 0805 PST		
Depth (m)	**Temp. (C)**	**D.O. (mg/l)**	**Depth (m)**	**Temp. (C)**	**D.O. (mg/l)**
0.0	12.7	9.4	0.0	14.0	9.9
0.5	12.6	9.4	0.5	14.0	10.0
1.0	12.6	9.3	1.0	14.0	10.0
1.5	12.5	9.4	1.5	14.0	10.0
2.0	12.5	9.4	2.0	14.0	10.0
2.5	12.5	9.4	2.5	14.0	10.0
3.0	12.5	9.4	3.0	14.0	10.0
3.5	12.5	9.5	3.5	14.0	10.0
4.0	12.5	9.5	4.0	14.0	9.9
4.5	12.5	9.5	4.5	14.0	9.9
5.0	12.5	9.4	5.0	14.0	9.9
5.5	12.5	9.4	5.5	13.9	9.9
6.0	12.5	9.4	6.0	13.9	9.9
6.5	12.4	9.4	6.5	13.9	9.9
Mean	12.5	9.4	Mean	14.0	10.0

August

Date: 8/22/2002 **Time:** 1540 PST			**Date:** 8/26/2002 **Time:** 1510 PST		
Depth (m)	**Temp. (C)**	**D.O. (mg/l)**	**Depth (m)**	**Temp. (C)**	**D.O. (mg/l)**
0.0	16.4	9.3	0.0	14.0	10.4
0.5	16.4	9.3	0.5	13.9	10.5
1.0	16.4	9.3	1.0	13.9	10.5
1.5	16.3	9.3	1.5	13.8	10.5
2.0	16.2	9.3	2.0	13.8	10.5
2.5	16.2	9.3	2.5	13.8	10.5
3.0	16.2	9.2	3.0	13.7	10.5
3.5	16.2	9.1	3.5	13.7	10.5
4.0	16.1	9.2	4.0	13.7	10.4
4.5	16.2	9.3	4.5	13.7	10.4
5.0	16.2	9.2	5.0	13.7	10.4
5.5	16.1	9.2	5.5	13.7	10.4
6.0	16.1	9.1	6.0	13.7	10.4
6.5	16.1	9.1	6.5	13.7	10.5
Mean	16.2	9.2	Mean	13.8	10.5

September

Date: 9/5/2002 **Time:** 1550 PST			**Date:** 9/27/2002 **Time:** 0845 PST		
Depth (m)	**Temp. (C)**	**D.O. (mg/l)**	**Depth (m)**	**Temp. (C)**	**D.O. (mg/l)**
0.0	12.4	10.8	0.0	11.7	10.4
0.5	12.4	10.9	0.5	11.7	10.4
1.0	12.4	10.9	1.0	11.7	10.2
1.5	12.4	10.9	1.5	11.7	10.3
2.0	12.3	10.8	2.0	11.7	10.3
2.5	12.3	10.8	2.5	11.7	10.3
3.0	12.2	10.9	3.0	11.6	10.3
3.5	12.3	10.8	3.5	11.6	10.3
4.0	12.2	10.8	4.0	11.6	10.3
4.5	12.2	10.9	4.5	11.6	10.3
5.0	12.1	10.8	5.0	11.6	10.3
5.5	12.1	10.7	5.5	11.6	10.3
6.0	12.1	10.8	6.0	11.6	10.2
6.5	12.1	10.6	6.5	11.6	10.2
Mean	12.3	10.8	Mean	11.6	10.3

October

Date: 10/9/2002 **Time:** 0850 PST			**Date:** 10/25/2002 **Time:** 0925 PST		
Depth (m)	**Temp. (C)**	**D.O. (mg/l)**	**Depth (m)**	**Temp. (C)**	**D.O. (mg/l)**
0.0	13.0	10.0	0.0	13.5	9.8
0.5	13.0	10.0	0.5	13.5	9.9
1.0	13.0	10.0	1.0	13.5	9.9
1.5	12.9	10.0	1.5	13.4	10.0
2.0	12.9	9.9	2.0	13.4	9.9
2.5	12.9	10.0	2.5	13.4	10.0
3.0	12.9	10.1	3.0	13.4	9.9
3.5	12.9	10.1	3.5	13.4	9.8
4.0	12.9	10.1	4.0	13.4	9.8
4.5	12.9	10.1	4.5	13.4	9.7
5.0	12.9	10.0	5.0	13.4	9.8
5.5	12.9	10.2	5.5	13.4	9.9
6.0	12.9	10.0	6.0	13.4	9.9
6.5	12.9	10.0	6.5	13.4	9.9
			7.0	13.4	9.9
Mean	12.9	10.0	Mean	13.4	9.9

Pool 1-3
Downstream from Hatchery

April

Date: 4/30/2002 **Time:** 1250 P.S.T.		
Depth (m)	**Temp. (C)**	**D.O. (mg/l)**
0.0	11.5	12
0.5	11.4	12
1.0	11.4	12
1.5	11.4	12
Mean	11.4	12.0

May

Date: 5/16/2002 **Time:** 0840 PST			**Date:** 5/30/2002 **Time:** 1340 PST		
Depth (m)	**Temp. (C)**	**D.O. (mg/l)**	**Depth (m)**	**Temp. (C)**	**D.O. (mg/l)**
0.0	11.5	N/A	0.0	13.4	11.1
0.5	11.4	N/A	0.5	13.4	11.1
1.0	11.4	N/A	1.0	13.4	11.1
1.5	11.4	N/A			
Mean	11.4	N/A	Mean	13.4	11.1

June

Date: 6/12/2002 **Time:** 1005 PST			**Date:** 6/27/2002 **Time:** 1000 PST		
Depth (m)	**Temp. (C)**	**D.O. (mg/l)**	**Depth (m)**	**Temp. (C)**	**D.O. (mg/l)**
0.0	12.8	11.3	0.0	14.5	11.1
0.5	12.7	11.3	0.5	14.4	11.1
1.0	12.7	11.3	1.0	14.4	11.1
1.5	12.7	11.3	1.5	14.4	11.1
Mean	12.7	11.3	Mean	14.4	11.1

July

Date: 7/15/2002 **Time:** 0920 PST			**Date:** 7/25/2002 **Time:** 0830 PST		
Depth (m)	**Temp. (C)**	**D.O. (mg/l)**	**Depth (m)**	**Temp. (C)**	**D.O. (mg/l)**
0.0	13.1	10.2	0.0	14.3	10.6
0.5	13.1	10.2	0.5	14.3	10.6
1.0	13.0	10.3	1.0	14.3	10.6
1.5	13.0	10.2	1.5	14.3	10.6
			2.0	14.3	10.5
Mean	13.1	10.2	Mean	14.3	10.6

August

Date: 8/22/2002 **Time:** 1515 PST			**Date:** 8/26/2002 **Time:** 1500 PST		
Depth (m)	**Temp. (C)**	**D.O. (mg/l)**	**Depth (m)**	**Temp. (C)**	**D.O. (mg/l)**
0.0	16.9	10.0	0.0	14.1	10.9
0.5	16.9	10.0	0.5	14.1	10.9
1.0	16.9	10.0	1.0	14.0	10.7
1.5	16.9	10.0	1.5	14.0	10.8
2.0	16.9	10.0	2.0	14.0	10.8
Mean	16.9	10.0	Mean	14.0	10.8

September

Date: 9/5/2002 **Time:** 1510 PST			**Date:** 9/27/2002 **Time:** 0810 PST		
Depth (m)	**Temp. (C)**	**D.O. (mg/l)**	**Depth (m)**	**Temp. (C)**	**D.O. (mg/l)**
0.0	12.6	11.2	0.0	11.6	10.4
0.5	12.5	11.2	0.5	11.6	10.4
1.0	12.5	11.2	1.0	11.6	10.4
1.5	12.5	11.2	1.5	11.6	10.4
2.0	12.5	11.1			
Mean	12.5	11.2	Mean	11.6	10.4

October

Date: 10/9/2002 **Time:** 1510 PST			**Date:** 10/25/2002 **Time:** 1005 PST		
Depth (m)	**Temp. (C)**	**D.O. (mg/l)**	**Depth (m)**	**Temp. (C)**	**D.O. (mg/l)**
0.0	13.7	10.5	0.0	13.3	10.1
0.5	13.6	10.5	0.5	13.3	10.1
1.0	13.6	10.5	1.0	13.3	10.1
1.5	13.6	10.5			
Mean	13.6	10.5	Mean	13.3	10.1

Pool 1-4
Upstream from Highway 162 Bridge

August

Date: 8/22/2002 **Time:** 1500 PST			**Date:** 8/26/2002 **Time:** 1450 PST		
Depth (m)	**Temp. (C)**	**D.O. (mg/l)**	**Depth (m)**	**Temp. (C)**	**D.O. (mg/l)**
0.0	18.2	11.1	0.0	15.0	11.0
0.5	18.2	11.1	0.5	15.0	11.1
1.0	18.2	11.2	1.0	14.9	11.0
1.5	18.1	11.2	1.5	14.9	11.0
2.0	18.0	11.2	2.0	14.8	10.9
2.5	18.0	11.3	2.5	14.8	10.9
3.0	18.0	11.2	3.0	14.8	10.9
3.5	18.0	11.1	3.5	14.8	10.9
4.0	17.9	11.0	4.0	14.8	10.8
Mean	18.1	11.2	Mean	14.9	10.9

September

Date: 9/5/2002 **Time:** 1455 PST			**Date:** 9/27/2002 **Time:** 0755 PST		
Depth (m)	**Temp. (C)**	**D.O. (mg/l)**	**Depth (m)**	**Temp. (C)**	**D.O. (mg/l)**
0.0	14.3	11.2	0.0	11.7	9.2
0.5	14.2	11.4	0.5	11.7	9.1
1.0	14.1	11.7	1.0	11.6	9.1
1.5	14.0	11.9	1.5	11.6	9.1
2.0	14.0	11.9	2.0	11.6	9.1
2.5	13.9	11.8	2.5	11.6	9.1
3.0	13.9	11.8	3.0	11.6	9.0
			3.5	11.6	8.9
Mean	14.1	11.7	Mean	11.6	9.1

October

Date: 10/8/2002 **Time:** 1500 PST			**Date:** 10/25/2002 **Time:** 1050 PST		
Depth (m)	**Temp. (C)**	**D.O. (mg/l)**	**Depth (m)**	**Temp. (C)**	**D.O. (mg/l)**
0.0	14.9	11.5	0.0	13.4	9.8
0.5	14.8	11.4	0.5	13.4	9.8
1.0	14.8	11.4	1.0	13.3	9.7
1.5	14.7	11.4	1.5	13.3	9.7
2.0	14.6	11.4	2.0	13.3	9.5
2.5	14.6	11.4	2.5	13.3	9.6
3.0	14.6	11.4	3.0	13.3	9.6
3.5	14.6	11.4	3.5	13.3	9.5
Mean	14.7	11.4	Mean	13.3	9.7

Pool 2-1
Upstream from Afterbay Outlet Pool

August

Date: 8/22/2002 **Time:** 1420 PST			**Date:** 8/26/2002 **Time:** 1425 PST		
Depth (m)	**Temp. (C)**	**D.O. (mg/l)**	**Depth (m)**	**Temp. (C)**	**D.O. (mg/l)**
0.0	18.5	9.9	0.0	16.5	10.4
0.5	18.5	10.1	0.5	16.4	10.6
1.0	18.4	10.1	1.0	16.3	10.7
1.5	18.4	10.1	1.5	16.2	10.7
2.0	18.4	10.1	2.0	16.2	10.7
2.5	18.3	10.1	2.5	16.2	10.6
3.0	18.3	10.0	3.0	16.2	10.7
3.5	18.3	10.0	3.5	16.2	10.7
4.0	18.3	10.0	4.0	16.2	10.7
4.5	18.3	10.0	4.5	16.2	10.7
			5.0	16.2	10.5
Mean	18.4	10	Mean	16.3	10.6

September

Date: 9/5/2002 **Time:** 1320 PST			**Date:** 9/27/2002 **Time:** 0715 PST		
Depth (m)	**Temp. (C)**	**D.O. (mg/l)**	**Depth (m)**	**Temp. (C)**	**D.O. (mg/l)**
0.0	15.0	10.6	0.0	13.3	9.0
0.5	14.9	10.7	0.5	13.3	9.0
1.0	14.9	10.7	1.0	13.3	8.9
1.5	14.9	10.6	1.5	13.3	8.9
2.0	14.9	10.6	2.0	13.3	8.9
2.5	14.8	10.5	2.5	13.3	8.9
3.0	14.8	10.5	3.0	13.3	8.9
3.5	14.8	10.4	3.5	13.3	8.9
4.0	14.8	10.4	4.0	13.3	8.8
4.5	14.8	10.3	4.5	13.3	8.7
5.0	14.8	10.3			
Mean	14.9	10.5	Mean	13.3	8.9

October

Date: 10/8/2002 **Time:** 1310 PST			**Date:** 10/24/2002 **Time:** 1345 PST		
Depth (m)	**Temp. (C)**	**D.O. (mg/l)**	**Depth (m)**	**Temp. (C)**	**D.O. (mg/l)**
0.0	15.1	10.4	0.0	13.8	9.9
0.5	15.1	10.4	0.5	13.8	10.0
1.0	15.0	10.5	1.0	13.8	10.0
1.5	15.0	10.5	1.5	13.8	10.0
2.0	15.0	10.5	2.0	13.8	10.0
2.5	15.0	10.4	2.5	13.7	10.0
3.0	15.0	10.4	3.0	13.7	10.0
3.5	14.9	10.4	3.5	13.7	10.0
4.0	14.9	10.3	4.0	13.7	10.1
Mean	15.0	10.4	Mean	13.8	10.0

Pool 2-2
At Afterbay Outlet Pool

August

Date: 8/22/2002 **Time:** 1415 PST			**Date:** 8/26/2002 **Time:** 1410 PST		
Depth (m)	**Temp. (C)**	**D.O. (mg/l)**	**Depth (m)**	**Temp. (C)**	**D.O. (mg/l)**
0.0	17.8	10.2	0.0	18.6	10.1
0.5	17.8	10.2	0.5	18.6	10.1
1.0	17.8	10.2	1.0	18.5	10.0
1.5	17.8	10.1	1.5	18.2	10.0
2.0	17.8	10.1	2.0	17.7	10.3
2.5	17.8	10.1	2.5	17.8	10.3
3.0	17.8	10.1	3.0	17.5	10.3
3.5	17.8	10.1	3.5	17.5	10.3
4.0	17.8	10.1	4.0	17.5	10.3
4.5	17.8	10.2	4.5	17.4	10.3
5.0	17.8	10.2	5.0	17.4	10.3
5.5	17.8	10.2	5.5	17.3	10.3
6.0	17.8	10.1	6.0	17.2	10.4
			6.5	17.1	10.3
			7.0	16.8	10.5
Mean	17.8	10.1	Mean	17.7	10.3

September

Date: 9/5/2002 **Time:** 1315 PST			**Date:** 9/27/2002 **Time:** 0645 PST		
Depth (m)	**Temp. (C)**	**D.O. (mg/l)**	**Depth (m)**	**Temp. (C)**	**D.O. (mg/l)**
0.0	16.4	10.3	0.0	14.6	10.0
0.5	16.3	10.4	0.5	14.6	10.0
1.0	16.3	10.4	1.0	14.6	10.1
1.5	16.3	10.4	1.5	14.6	10.0
2.0	16.2	10.4	2.0	14.6	10.1
2.5	16.2	10.4	2.5	14.6	10.1
3.0	16.1	10.4	3.0	14.6	10.1
3.5	15.7	10.6	3.5	14.6	10.1
4.0	15.2	10.9	4.0	14.6	10.0
4.5	15.1	10.9	4.5	14.6	10.1
5.0	15.0	10.8	5.0	14.6	10.1
5.5	15.0	10.7	5.5	14.6	10.1
6.0	15.0	10.7			
Mean	15.8	10.6	Mean	14.6	10.1

October

Date: 10/8/2002 **Time:** 1300 PST			**Date:** 10/24/2002 **Time:** 1335 PST		
Depth (m)	**Temp. (C)**	**D.O. (mg/l)**	**Depth (m)**	**Temp. (C)**	**D.O. (mg/l)**
0.0	16.0	10.2	0.0	14.6	9.9
0.5	15.9	10.3	0.5	14.6	9.8
1.0	15.9	10.4	1.0	14.6	9.8
1.5	15.9	10.4	1.5	14.6	9.7
2.0	15.9	10.4	2.0	14.6	9.7
2.5	15.9	10.3	2.5	14.6	9.7
3.0	15.8	10.3	3.0	14.6	9.7
3.5	15.8	10.3	3.5	14.6	9.7
4.0	15.8	10.3	4.0	14.6	9.7
4.5	15.8	10.3	4.5	14.6	9.7
5.0	15.8	10.2	5.0	14.6	9.7
			5.5	14.6	9.7
			6.0	14.6	9.7
			6.5	14.6	9.7
			7.0	14.6	9.7
Mean	15.9	10.3	Mean	14.6	9.7

Pool 3-1
Downstream from Afterbay Outlet Pool

August

Date: 8/22/2002 **Time:** 1245 PST			**Date:** 8/26/2002 **Time:** 1245 PST		
Depth (m)	**Temp. (C)**	**D.O. (mg/l)**	**Depth (m)**	**Temp. (C)**	**D.O. (mg/l)**
0.0	17.3	10.3	0.0	18.0	10.0
0.5	17.3	10.3	0.5	18.0	10.0
1.0	17.3	10.3	1.0	18.0	10.0
1.5	17.3	10.3	1.5	18.0	10.0
2.0	17.3	10.3	2.0	18.0	9.9
2.5	17.3	10.3	2.5	18.0	9.9
3.0	17.3	10.3			
Mean	17.3	10.3	Mean	18.0	10.0

September

Date: 9/5/2002 **Time:** 1305 PST			**Date:** 9/26/2002 **Time:** 1300 PST		
Depth (m)	**Temp. (C)**	**D.O. (mg/l)**	**Depth (m)**	**Temp. (C)**	**D.O. (mg/l)**
0.0	16.8	10.5	0.0	15.8	10.9
0.5	16.7	10.5	0.5	15.7	10.9
1.0	16.7	10.5	1.0	15.7	10.9
1.5	16.7	10.5	1.5	15.7	10.9
2.0	16.7	10.5	2.0	15.7	10.8
2.5	16.7	10.4	2.5	15.7	10.8
3.0	16.7	10.4	3.0	15.7	10.8
			3.5	15.7	10.7
Mean	16.7	10.5	Mean	15.7	10.1

October

Date: 10/8/2002 **Time:** 1245 PST			**Date:** 10/24/2002 **Time:** 1330 PST		
Depth (m)	**Temp. (C)**	**D.O. (mg/l)**	**Depth (m)**	**Temp. (C)**	**D.O. (mg/l)**
0.0	16.0	10.6	0.0	14.6	9.9
0.5	15.9	10.6	0.5	14.6	9.9
1.0	15.7	10.6	1.0	14.6	9.9
1.5	15.9	10.6	1.5	14.6	9.9
2.0	15.9	10.5	2.0	14.6	9.9
Mean	15.9	10.6	Mean	14.6	9.9

Pool 3-2
Near Mile Long Pool

August

Date: 8/22/2002 **Time:** 1235 PST			**Date:** 8/26/2002 **Time:** 1235 PST		
Depth (m)	**Temp. (C)**	**D.O. (mg/l)**	**Depth (m)**	**Temp. (C)**	**D.O. (mg/l)**
0.0	17.6	10.6	0.0	18.8	9.7
0.5	17.6	10.6	0.5	18.7	9.7
1.0	17.6	10.6	1.0	18.7	9.7
1.5	17.6	10.6	1.5	18.7	9.6
2.0	17.5	10.6	2.0	18.7	9.6
2.5	17.5	10.6	2.5	18.7	9.6
Mean	17.6	10.6	Mean	18.7	9.7

September

Date: 9/5/2002 **Time:** 1255 PST			**Date:** 9/26/2002 **Time:** 1255 PST		
Depth (m)	**Temp. (C)**	**D.O. (mg/l)**	**Depth (m)**	**Temp. (C)**	**D.O. (mg/l)**
0.0	17.3	10.2	0.0	16.3	10.6
0.5	17.2	10.4	0.5	16.3	10.6
1.0	17.2	10.4	1.0	16.2	10.5
1.5	17.2	10.3	1.5	16.2	10.5
2.0	17.2	10.3			
Mean	17.2	10.3	Mean	16.3	10.6

October

Date: 10/8/2002 **Time:** 1230 PST			**Date:** 10/24/2002 **Time:** 1315 PST		
Depth (m)	**Temp. (C)**	**D.O. (mg/l)**	**Depth (m)**	**Temp. (C)**	**D.O. (mg/l)**
0.0	16.8	10.2	0.0	14.8	9.6
0.5	16.7	10.2	0.5	14.8	9.6
1.0	16.5	10.5	1.0	14.8	9.7
1.5	16.4	10.5	1.5	14.8	9.8
Mean	16.6	10.4	Mean	14.8	9.7

Pool 3-3
Downstream from Project Boundary Pool

August

Date: 8/22/2002 **Time:** 1500 PST			**Date:** 8/26/2002 **Time:** 1220 PST		
Depth (m)	**Temp. (C)**	**D.O. (mg/l)**	**Depth (m)**	**Temp. (C)**	**D.O. (mg/l)**
0.0	17.9	10.8	0.0	18.8	10.2
0.5	17.9	10.7	0.5	18.8	10.2
1.0	17.8	10.7	1.0	18.8	10.2
1.5	17.8	10.7	1.5	18.7	10.2
2.0	17.8	10.6	2.0	18.7	10.2
2.5	17.8	10.6	2.5	18.7	10.1
3.0	17.8	10.6	3.0	18.7	10.0
3.5	17.8	10.6	3.5	18.7	10.0
4.0	17.8	10.6	4.0	18.7	10.0
Mean	17.8	10.6	Mean	18.7	10.1

September

Date: 9/5/2002 **Time:** 1245 PST			**Date:** 9/26/2002 **Time:** 1240 PST		
Depth (m)	**Temp. (C)**	**D.O. (mg/l)**	**Depth (m)**	**Temp. (C)**	**D.O. (mg/l)**
0.0	17.5	10.8	0.0	16.8	11.2
0.5	17.4	10.8	0.5	16.8	11.2
1.0	17.4	10.8	1.0	16.7	11.2
1.5	17.4	10.8	1.5	16.7	11.1
2.0	17.4	10.8	2.0	16.8	11.1
2.5	17.3	10.7	2.5	16.8	11.0
3.0	17.3	10.7	3.0	16.8	11.0
3.5	17.3	10.7	3.5	16.8	11.0
4.0	17.3	10.7	4.0	16.7	11.0
4.5	17.3	10.7			
Mean	17.4	10.8	Mean	16.8	11.1

October

Date: 10/8/2002 **Time:** 1220 PST			**Date:** 10/24/2002 **Time:** 1300 PST		
Depth (m)	**Temp. (C)**	**D.O. (mg/l)**	**Depth (m)**	**Temp. (C)**	**D.O. (mg/l)**
0.0	16.9	10.6	0.0	15.0	9.9
0.5	16.8	10.7	0.5	15.0	10.0
1.0	16.8	10.7	1.0	15.0	10.1
1.5	16.7	10.7	1.5	15.0	10.1
2.0	16.7	10.6	2.0	15.0	10.1
2.5	16.7	10.6	2.5	15.0	10.1
3.0	16.7	10.6	3.0	15.0	10.1
3.5	16.7	10.6	3.5	15.0	10.1
4.0	16.7	10.4	4.0	15.0	10.1
4.25	16.7	10.2			
Mean	16.7	10.6	Mean	15.0	9.9

Pool 3-4
Near Gridley Pool

August

Date: 8/22/2002 **Time:** 1205 PST			**Date:** 8/26/2002 **Time:** 1205 PST		
Depth (m)	**Temp. (C)**	**D.O. (mg/l)**	**Depth (m)**	**Temp. (C)**	**D.O. (mg/l)**
0.0	17.8	10.6	0.0	19.1	9.7
0.5	17.8	10.6	0.5	19.1	9.7
1.0	17.8	10.6	1.0	19.0	9.7
1.5	17.8	10.6	1.5	19.0	9.7
2.0	17.7	10.5	2.0	19.0	9.8
2.5	17.7	10.5	2.5	19.0	9.7
3.0	17.7	10.5	3.0	19.0	9.7
3.5	17.7	10.5	3.5	19.0	9.7
4.0	17.7	10.5	4.0	19.0	9.7
4.5	17.7	10.5	4.5	19.0	9.7
Mean	17.7	10.5	Mean	19	9.7

September

Date: 9/5/2002 **Time:** 1230 PST			**Date:** 9/26/2002 **Time:** 1230 PST		
Depth (m)	**Temp. (C)**	**D.O. (mg/l)**	**Depth (m)**	**Temp. (C)**	**D.O. (mg/l)**
0.0	17.3	10.4	0.0	16.8	10.8
0.5	17.2	10.5	0.5	16.8	10.7
1.0	17.2	10.5	1.0	16.8	10.7
1.5	17.2	10.6	1.5	16.7	10.7
2.0	17.2	10.6	2.0	16.7	10.7
2.5	17.1	10.6	2.5	16.7	10.7
3.0	17.1	10.6	3.0	16.7	10.7
3.5	17.1	10.6	3.5	16.7	10.7
4.0	17.1	10.6	4.0	16.7	10.7
4.5	17.0	10.5	4.5	16.7	10.7
5.0	17.1	10.1	5.0	16.7	10.7
5.5	17.1	10.1			
Mean	17.1	10.5	Mean	16.8	10.7

October

Date: 10/8/2002 **Time:** 1200 PST			**Date:** 10/24/2002 **Time:** 1245 PST		
Depth (m)	**Temp. (C)**	**D.O. (mg/l)**	**Depth (m)**	**Temp. (C)**	**D.O. (mg/l)**
0.0	16.6	10.2	0.0	14.8	9.8
0.5	16.6	10.1	0.5	14.8	9.8
1.0	16.6	10.1	1.0	14.8	9.8
1.5	16.6	10.1	1.5	14.8	9.8
2.0	16.5	10.1	2.0	14.8	9.8
2.5	16.5	10.1	2.5	14.8	9.8
3.0	16.5	10.1	3.0	14.8	9.8
3.5	16.5	10.1	3.5	14.8	9.8
4.0	16.5	10.1	4.0	14.8	9.8
4.5	16.5	10.1	4.5	14.8	9.7
			5.0	14.8	9.7
Mean	16.5	10.1	Mean	14.8	9.9

Pool 3-5
Upstream from Honcut Creek

August

Date: 8/22/2002 **Time:** 1150 PST			**Date:** 8/26/2002 **Time:** 1150 PST		
Depth (m)	**Temp. (C)**	**D.O. (mg/l)**	**Depth (m)**	**Temp. (C)**	**D.O. (mg/l)**
0.0	17.8	9.9	0.0	19.3	9.2
0.5	17.8	9.9	0.5	19.3	9.1
1.0	17.7	9.9	1.0	19.2	9.1
1.5	17.7	9.9	1.5	19.2	8.9
2.0	17.7	9.8	2.0	19.2	8.8
2.5	17.7	9.8	2.5	19.2	9.0
3.0	17.7	9.8	3.0	19.2	9.0
Mean	17.7	9.9	Mean	19.2	9.0

September

Date: 9/5/2002 **Time:** 1215 PST			**Date:** 9/26/2002 **Time:** 1210 PST		
Depth (m)	**Temp. (C)**	**D.O. (mg/l)**	**Depth (m)**	**Temp. (C)**	**D.O. (mg/l)**
0.0	16.8	9.9	0.0	16.8	9.5
0.5	16.8	9.9	0.5	16.7	9.7
1.0	16.8	10.0	1.0	16.7	9.7
1.5	16.8	10.0	1.5	16.6	9.7
2.0	16.8	10.0	2.0	16.5	9.8
2.5	16.8	10.0	2.5	16.5	9.8
3.0	16.8	9.9	3.0	16.5	9.7
			3.5	16.5	9.8
Mean	16.8	10.0	Mean	16.6	9.7

October

Date: 10/8/2002 **Time:** 1145 PST			**Date:** 10/24/2002 **Time:** 1230 PST		
Depth (m)	**Temp. (C)**	**D.O. (mg/l)**	**Depth (m)**	**Temp. (C)**	**D.O. (mg/l)**
0.0	16.5	9.0	0.0	14.7	8.9
0.5	16.4	9.3	0.5	14.7	8.8
1.0	16.3	9.3	1.0	14.7	8.8
1.5	16.3	9.2	1.5	14.7	8.8
2.0	16.2	9.2	2.0	14.7	8.8
2.5	16.2	9.1	2.5	14.7	8.8
3.0	16.2	9.0			
Mean	16.3	9.2	Mean	14.7	8.8

Pool 4-1
At Archer Avenue Pool

August

Date: 8/22/2002 **Time:** 1130 PST			**Date:** 8/26/2002 **Time:** 1130 PST		
Depth (m)	**Temp. (C)**	**D.O. (mg/l)**	**Depth (m)**	**Temp. (C)**	**D.O. (mg/l)**
0.0	18.0	9.6	0.0	19.6	8.8
0.5	18.0	9.6	0.5	19.6	8.8
1.0	17.9	9.6	1.0	19.5	8.8
1.5	17.9	9.6	1.5	19.5	8.8
2.0	17.9	9.6	2.0	19.5	8.7
2.5	17.9	9.6			
3.0	17.9	9.6			
Mean	17.9	9.6	Mean	19.5	8.8

September

Date: 9/5/2002 **Time:** 1200 PST			**Date:** 9/26/2002 **Time:** 1150 PST		
Depth (m)	**Temp. (C)**	**D.O. (mg/l)**	**Depth (m)**	**Temp. (C)**	**D.O. (mg/l)**
0.0	16.8	9.7	0.0	16.8	9.8
0.5	16.8	9.7	0.5	16.7	9.7
1.0	16.8	9.7	1.0	16.7	9.7
1.5	16.8	9.6	1.5	16.7	9.7
2.0	16.8	9.6	2.0	16.7	9.7
2.5	16.8	9.5	2.5	16.7	9.7
			3.0	16.7	9.7
Mean	16.8	9.6	Mean	16.7	9.7

October

Date: 10/8/2002 **Time:** 1130 PST			**Date:** 10/24/2002 **Time:** 1205 PST		
Depth (m)	**Temp. (C)**	**D.O. (mg/l)**	**Depth (m)**	**Temp. (C)**	**D.O. (mg/l)**
0.0	16.7	9.5	0.0	15.0	9.2
0.5	16.6	9.5	0.5	15.0	9.2
1.0	16.6	9.5	1.0	15.0	9.1
1.5	16.6	9.5	1.5	15.0	9.1
2.0	16.6	9.5	2.0	15.0	9.1
2.5	16.6	9.5	2.5	15.0	9.1
			3.0	15.0	9.1
			3.5	15.0	9.1
			4.0	15.0	9.1
			4.5	15.0	9.1
			5.0	15.0	9.1
Mean	16.6	9.5	Mean	15.0	9.1

Pool 4-2
Upstream from Yuba River Pool

August

Date: 8/07/2002 **Time:** 1240 PST			**Date:** 8/22/2002 **Time:** 1100 PST			**Date:** 8/26/2002 **Time:** 1100 PST		
Depth (m)	**Temp. (C)**	**D.O. (mg/l)**	**Depth (m)**	**Temp. (C)**	**D.O. (mg/l)**	**Depth (m)**	**Temp. (C)**	**D.O. (mg/l)**
0.0	20.1	9.2	0.0	18.6	9.1	0.0	20.2	8.6
0.5	20.1	9.1	0.5	18.6	9.1	0.5	20.1	8.6
1.0	20.0	9.1	1.0	18.6	9.1	1.0	20.1	8.6
1.5	20.0	9.1	1.5	18.6	9.1	1.5	20.1	8.6
2.0	20.0	9.1	2.0	18.6	9.1			
Mean	20.0	9.1	Mean	18.6	9.1	Mean	20.1	8.6

September

Date: 9/5/2002 **Time:** 0955 PST			**Date:** 9/26/2002 **Time:** 1110 PST		
Depth (m)	**Temp. (C)**	**D.O. (mg/l)**	**Depth (m)**	**Temp. (C)**	**D.O. (mg/l)**
0.0	17.3	9.3	0.0	18.0	9.3
0.5	17.3	9.3	0.5	17.9	9.3
1.0	17.2	9.4	1.0	17.9	9.3
1.5	17.2	9.4	1.5	17.9	9.3
2.0	17.2	9.4			
Mean	17.2	9.4	Mean	17.9	9.3

October

Date: 10/8/2002 **Time:** 1045 PST			**Date:** 10/24/2002 **Time:** 1100 PST		
Depth (m)	**Temp. (C)**	**D.O. (mg/l)**	**Depth (m)**	**Temp. (C)**	**D.O. (mg/l)**
0.0	17.0	9.4	0.0	14.9	8.8
0.5	17.0	9.4	0.5	14.9	8.8
1.0	17.0	9.4	1.0	14.9	8.8
1.5	17.0	9.4	1.5	14.9	8.8
Mean	17.0	9.4	Mean	14.9	8.8

Pool 4-3
At Shanghai Bend Pool

August

Date: 8/07/2002 **Time:** 1100 PST			**Date:** 8/22/2002 **Time:** 1015 PST			**Date:** 8/26/2002 **Time:** 1015 PST		
Depth (m)	**Temp. (C)**	**D.O. (mg/l)**	**Depth (m)**	**Temp. (C)**	**D.O. (mg/l)**	**Depth (m)**	**Temp. (C)**	**D.O. (mg/l)**
0.0	18.8	9.5	0.0	18.5	9.1	0.0	19.5	8.6
0.5	18.8	9.5	0.5	18.5	9.1	0.5	19.5	8.6
1.0	18.7	9.4	1.0	18.5	9.0	1.0	19.5	8.6
1.5	18.7	9.4	1.5	18.5	9.0	1.5	19.4	8.6
2.0	18.7	9.4	2.0	18.5	9.0	2.0	19.4	8.6
2.5	18.7	9.4	2.5	18.5	9.0	2.5	19.4	8.6
3.0	18.7	9.4	3.0	18.5	9.0	3.0	19.4	8.6
3.5	18.7	9.4	3.5	18.4	8.9	3.5	19.4	8.6
4.0	18.7	9.4	4.0	18.4	8.9	4.0	19.4	8.6
4.5	18.6	9.3				4.5	19.4	8.5
Mean	18.7	9.4	Mean	18.5	9.0	Mean	19.4	8.6

September

Date: 9/5/2002 **Time:** 1050 PST			**Date:** 9/26/2002 **Time:** 1030 PST		
Depth (m)	**Temp. (C)**	**D.O. (mg/l)**	**Depth (m)**	**Temp. (C)**	**D.O. (mg/l)**
0.0	17.5	9.3	0.0	18.0	9.3
0.5	17.5	9.3	0.5	18.0	9.3
1.0	17.5	9.4	1.0	18.0	9.3
1.5	17.5	9.4	1.5	18.0	9.3
2.0	17.4	9.1	2.0	18.0	9.2
2.5	17.4	9.3	2.5	18.0	9.1
3.0	17.4	9.3	3.0	18.0	9.1
3.5	17.4	9.3	3.5	18.0	9.1
4.0	17.4	9.2			
4.5	17.4	9.2			
5.0	17.4	9.4			
Mean	17.4	9.3	Mean	18.0	9.2

October

Date: 10/8/2002 **Time:** 0955 PST			**Date:** 10/24/2002 **Time:** 1000 PST		
Depth (m)	**Temp. (C)**	**D.O. (mg/l)**	**Depth (m)**	**Temp. (C)**	**D.O. (mg/l)**
0.0	17.0	9.4	0.0	14.8	9.2
0.5	17.0	9.4	0.5	14.8	9.2
1.0	17.0	9.4	1.0	14.8	9.2
1.5	17.0	9.5	1.5	14.8	9.2
2.0	17.0	9.4	2.0	14.8	9.2
2.5	17.0	9.3	2.5	14.8	9.2
3.0	17.0	9.3	3.0	14.8	9.2
3.5	17.0	9.3	3.5	14.8	9.1
4.0	17.0	9.3	4.0	14.8	9.0
4.5	17.0	9.2			
Mean	17.0	9.4	Mean	14.8	9.2

Pool 4-4
At Star Bend Pool

August

Date: 8/07/2002 **Time:** 1035 PST			**Date:** 8/22/2002 **Time:** 0950 PST			**Date:** 8/26/2002 **Time:** 0945 PST		
Depth (m)	**Temp. (C)**	**D.O. (mg/l)**	**Depth (m)**	**Temp. (C)**	**D.O. (mg/l)**	**Depth (m)**	**Temp. (C)**	**D.O. (mg/l)**
0.0	19.1	9.3	0.0	18.9	9.2	0.0	19.7	8.7
0.5	19.1	9.3	0.5	18.9	9.2	0.5	19.7	8.7
1.0	19.1	9.3	1.0	18.9	9.2	1.0	19.7	8.7
1.5	19.1	9.4	1.5	18.9	9.2	1.5	19.7	8.7
2.0	19.1	9.4	2.0	18.9	9.2	2.0	19.7	8.7
2.5	19.1	9.4	2.5	18.9	9.2	2.5	19.7	8.7
3.0	19.1	9.4	3.0	18.9	9.2	3.0	19.7	8.6
3.5	19.1	9.4	3.5	18.9	9.2	3.5	19.7	8.6
4.0	19.1	9.4	4.0	18.9	9.2	4.0	19.6	8.8
4.5	19.1	9.4	4.5	18.9	9.2	4.5	19.6	8.7
5.0	19.1	9.4	5.0	18.9	9.2	5.0	19.6	8.7
5.5	19.2	9.4	5.5	18.9	9.2	5.5	19.6	8.7
			6.0	18.9	9.2	6.0	19.6	8.7
			6.5	18.9	9.2			
			7.0	18.9	9.1			
Mean	19.1	9.4	Mean	18.9	9.2	Mean	19.7	8.7

September

Date: 9/5/2002 **Time:** 1030 PST			**Date:** 9/26/2002 **Time:** 1005 PST		
Depth (m)	**Temp. (C)**	**D.O. (mg/l)**	**Depth (m)**	**Temp. (C)**	**D.O. (mg/l)**
0.0	17.8	9.5	0.0	17.9	9.3
0.5	17.7	9.5	0.5	17.9	9.3
1.0	17.7	9.5	1.0	17.9	9.3
1.5	17.7	9.5	1.5	17.9	9.3
2.0	17.7	9.5	2.0	17.9	9.4
2.5	17.7	9.5	2.5	17.9	9.3
3.0	17.7	9.5	3.0	17.9	9.3
3.5	17.7	9.5	3.5	17.9	9.3
4.0	17.7	9.5	4.0	17.9	9.2
4.5	17.7	9.5			
5.0	17.7	9.5			
5.5	17.7	9.5			
6.0	17.7	9.3			
6.5	17.7	9.3			
Mean	17.7	9.5	Mean	17.9	9.3

October

Date: 10/8/2002 **Time:** 0930 PST			**Date:** 10/24/2002 **Time:** 0930 PST		
Depth (m)	**Temp. (C)**	**D.O. (mg/l)**	**Depth (m)**	**Temp. (C)**	**D.O. (mg/l)**
0.0	17.2	9.4	0.0	15.1	9.3
0.5	17.2	9.4	0.5	15.1	9.2
1.0	17.2	9.4	1.0	15.1	9.3
1.5	17.2	9.4	1.5	15.1	9.3
2.0	17.2	9.4	2.0	15.1	9.3
2.5	17.2	9.3	2.5	15.1	9.3
3.0	17.2	9.4	3.0	15.1	9.3
3.5	17.2	9.4	3.5	15.1	9.3
4.0	17.2	9.4	4.0	15.1	9.3
4.5	17.2	9.4	4.5	15.1	9.3
5.0	17.2	9.4	5.0	15.1	9.3
			5.5	15.1	9.3
			6.0	15.1	9.3
Mean	17.2	9.4	Mean	15.1	9.3

Pool 4-5
Near Verona Pool

August

Date: 8/07/2002 **Time:** 0900 PST			**Date:** 8/22/2002 **Time:** 0830 PST			**Date:** 8/26/2002 **Time:** 0830 PST		
Depth (m)	**Temp. (C)**	**D.O. (mg/l)**	**Depth (m)**	**Temp. (C)**	**D.O. (mg/l)**	**Depth (m)**	**Temp. (C)**	**D.O. (mg/l)**
0.0	19.2	9.1	0.0	18.9	8.8	0.0	19.7	8.6
0.5	19.2	9.1	0.5	18.9	8.8	0.5	19.7	8.6
1.0	19.2	9.1	1.0	18.9	8.8	1.0	19.7	8.6
1.5	19.2	9.1	1.5	18.9	8.8	1.5	19.7	8.6
2.0	19.2	9.1	2.0	18.9	8.8	2.0	19.7	8.6
2.5	19.2	9.1						
Mean	19.2	9.1	Mean	18.9	8.8	Mean	19.7	8.6

September

Date: 9/5/2002 **Time:** 0840 PST			**Date:** 9/26/2002 **Time:** 0900 PST		
Depth (m)	**Temp. (C)**	**D.O. (mg/l)**	**Depth (m)**	**Temp. (C)**	**D.O. (mg/l)**
0.0	18.5	8.9	0.0	18.8	8.9
0.5	18.5	8.9	0.5	18.8	8.9
1.0	18.5	8.9	1.0	18.8	8.9
1.5	18.5	8.8	1.5	18.8	8.9
2.0	18.5	8.8			
2.5	18.5	8.8			
3.0	18.5	8.8			
3.5	18.5	8.8			
Mean	18.5	8.8	Mean	18.8	8.9

October

Date: 10/8/2002 **Time:** 0930 PST			**Date:** 10/24/2002 **Time:** 0930 PST		
Depth (m)	**Temp. (C)**	**D.O. (mg/l)**	**Depth (m)**	**Temp. (C)**	**D.O. (mg/l)**
0.0	17.8	9.2	0.0	14.8	9.4
0.5	17.8	9.2	0.5	14.8	9.4
1.0	17.8	9.2	1.0	14.8	9.4
1.5	17.8	9.2			
Mean	17.8	9.2	Mean	14.8	9.4

State of California
The Resources Agency
Department of Water Resources

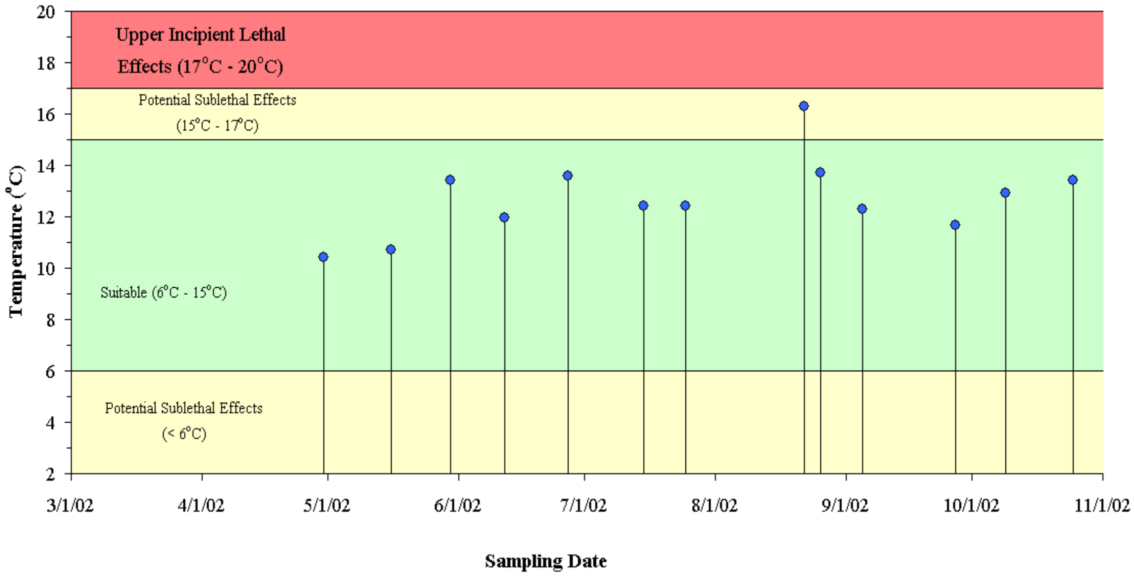
FINAL REPORT EVALUATION OF OROVILLE FACILITIES OPERATIONS ON WATER TEMPERATURE-RELATED EFFECTS ON PRE-SPAWNING ADULT CHINOOK SALMON AND CHARACTERIZATION OF HOLDING HABITAT SP-F10, TASKS 1D AND 1E

APPENDIX E
MEAN WATER COLUMN TEMPERATURES COLLECTED IN FEATHER RIVER POOLS (APRIL 2002 THROUGH OCTOBER 2002)

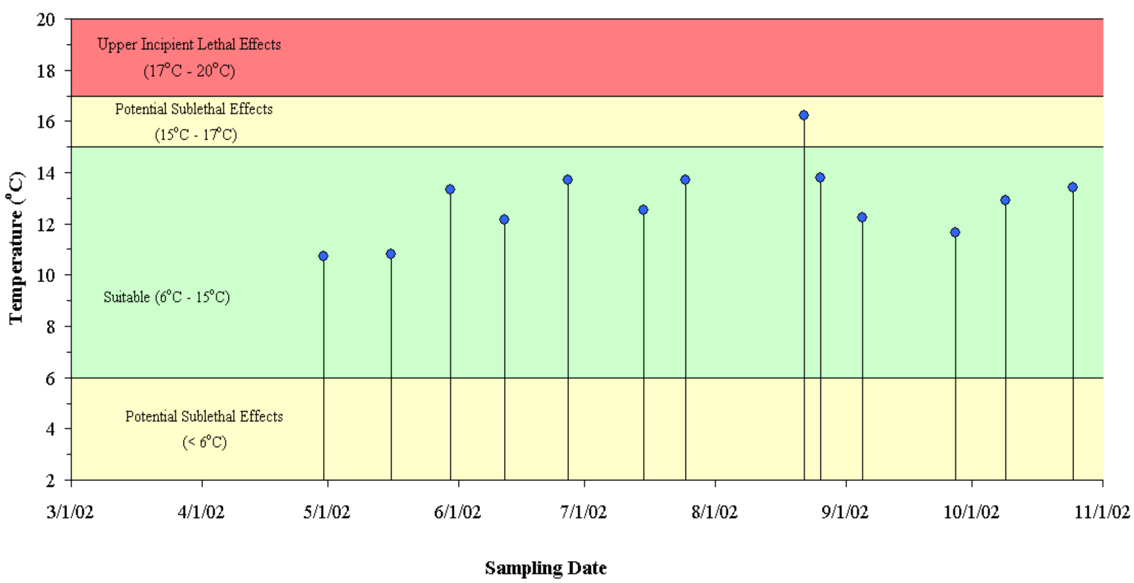
Oroville Facilities Relicensing
FERC Project No. 2100

JUNE 2004

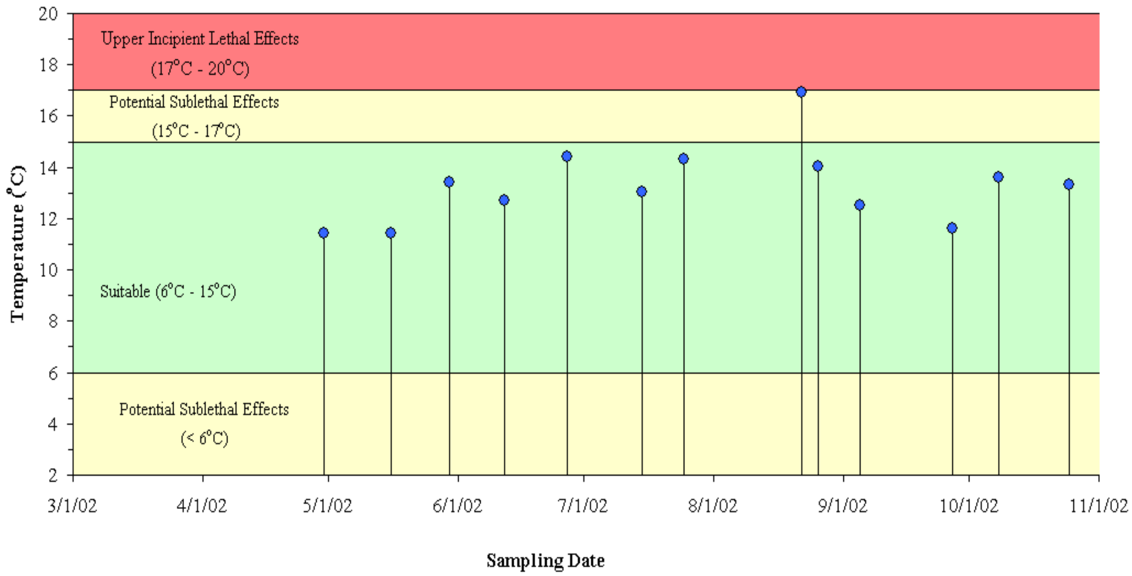
Feather River Downstream from Fish Barrier Dam
N 39º 31' 8.5" W 121º 32' 53"
Pool 1-1



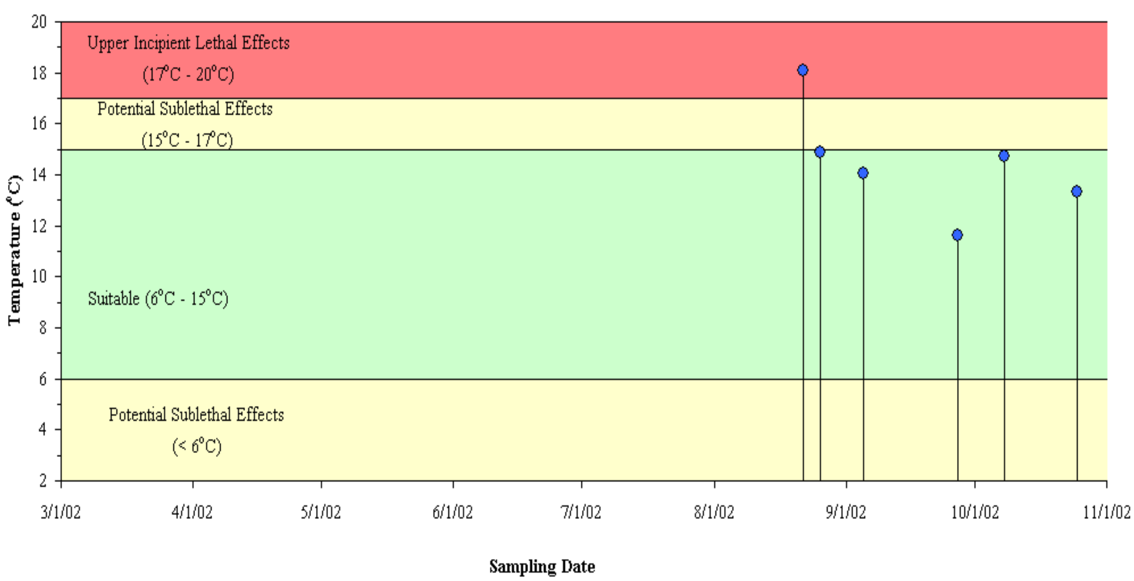
Feather River Upstream from Hatchery
N 39º 31' 3.5" W 121º 33' 1.2"
Pool 1-2



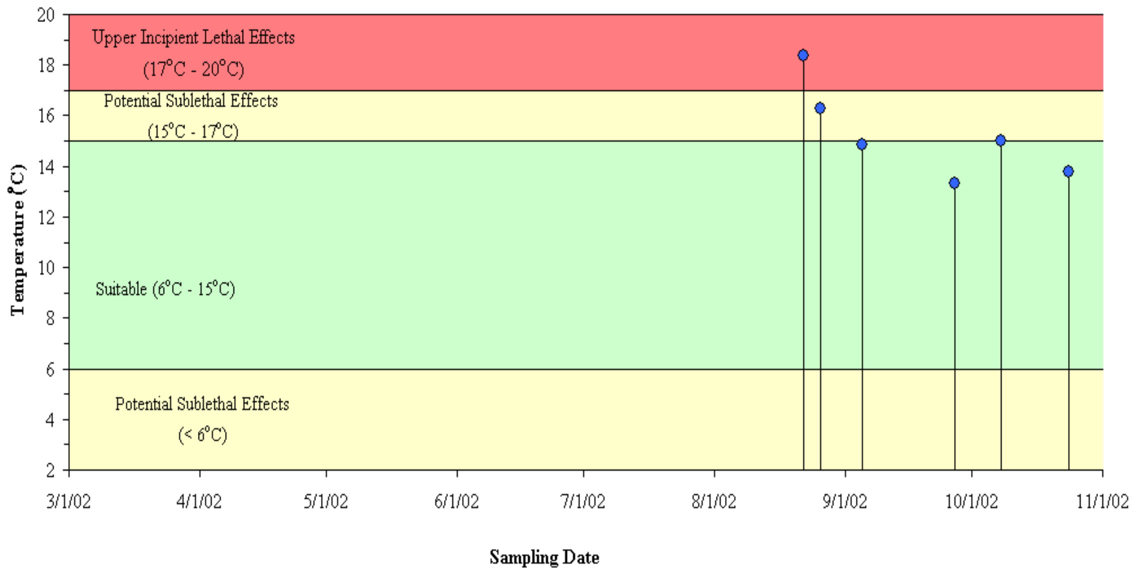
Feather River Downstream from Hatchery
N 39º 30' 55.1" W 121º 33' 44.7"
Pool 1-3



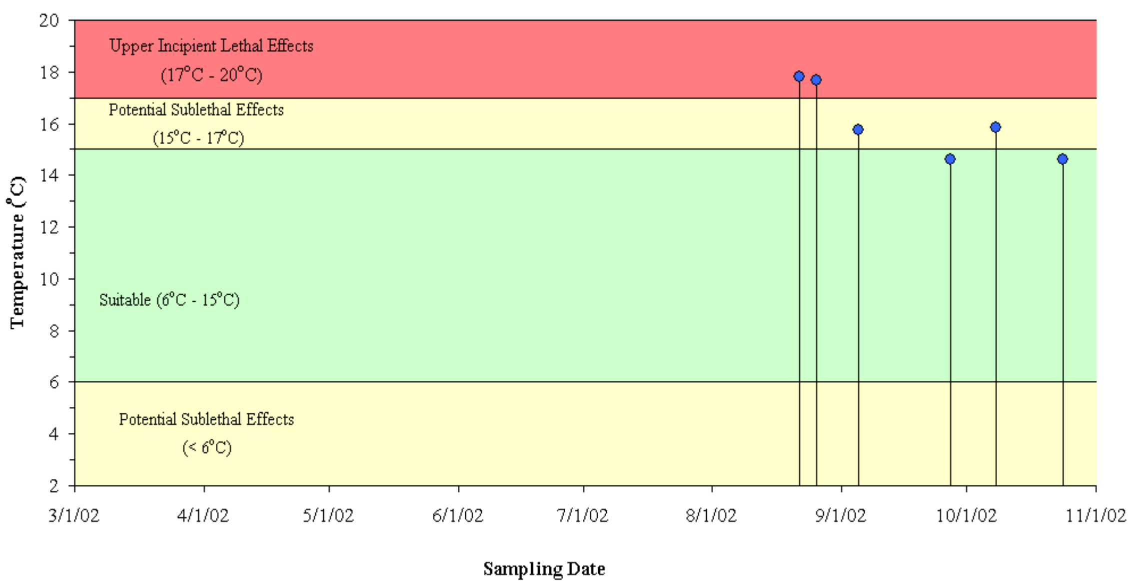
Feather River Upstream from Hwy 162 Bridge
N 39º 29' 53.3" W 121º 34' 45.4"
Pool 1-4



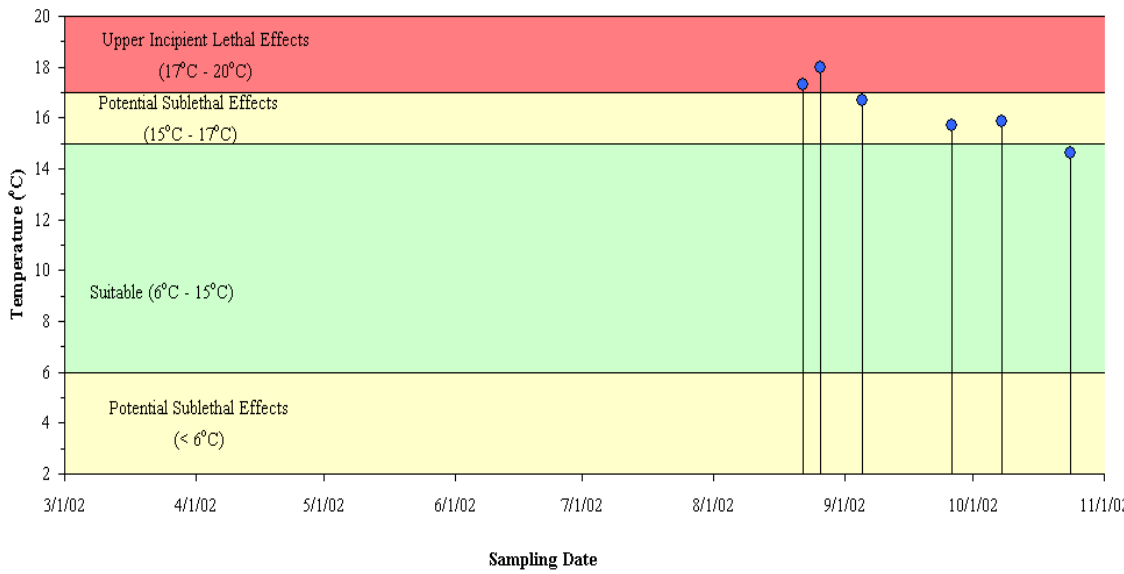
Feather River Upstream Afterbay Outlet
N 39º 27' 23.4" W 121º 37' 13.5"
Pool 2-1



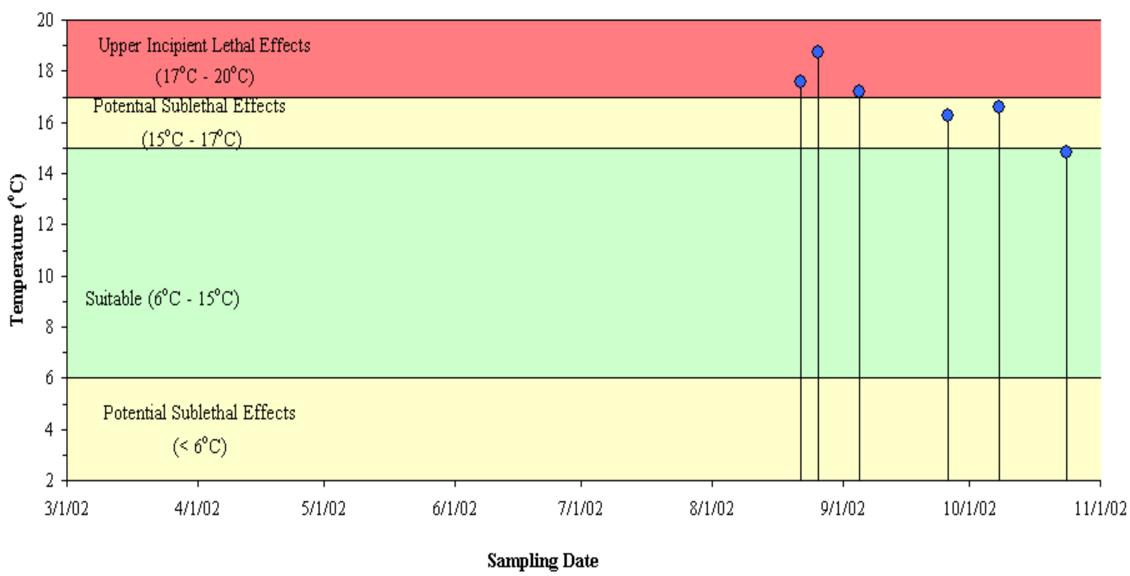
Feather River at Afterbay Outlet
N 39º 27' 18.2" W 121º 38' 10.5"
Pool 2-2



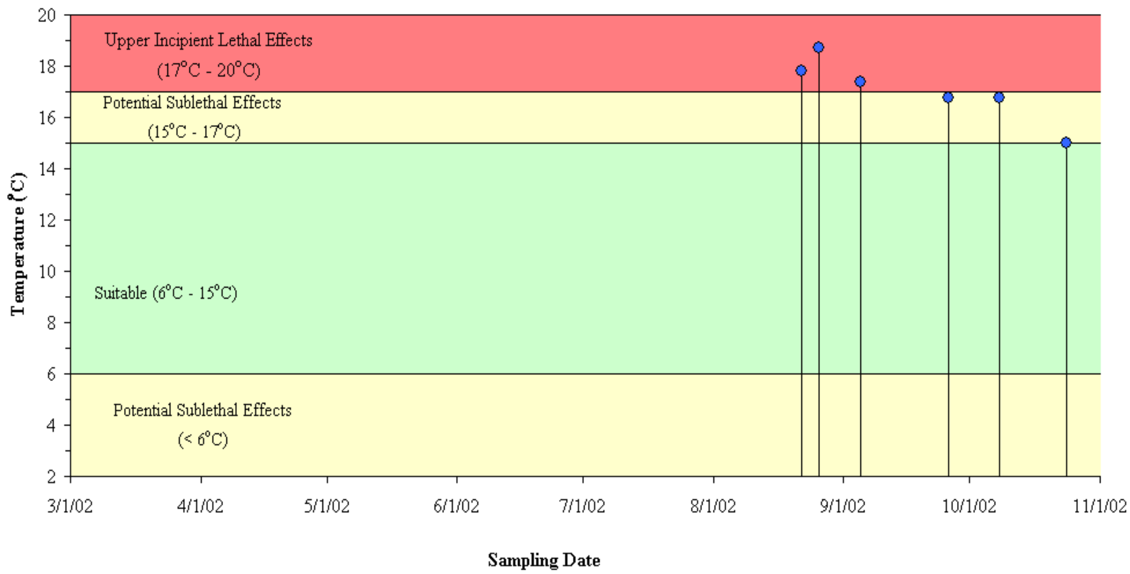
Feather River Downstream from Afterbay Outlet
N 39º 26' 48.8" W 121º 38' 15.7"
Pool 3-1



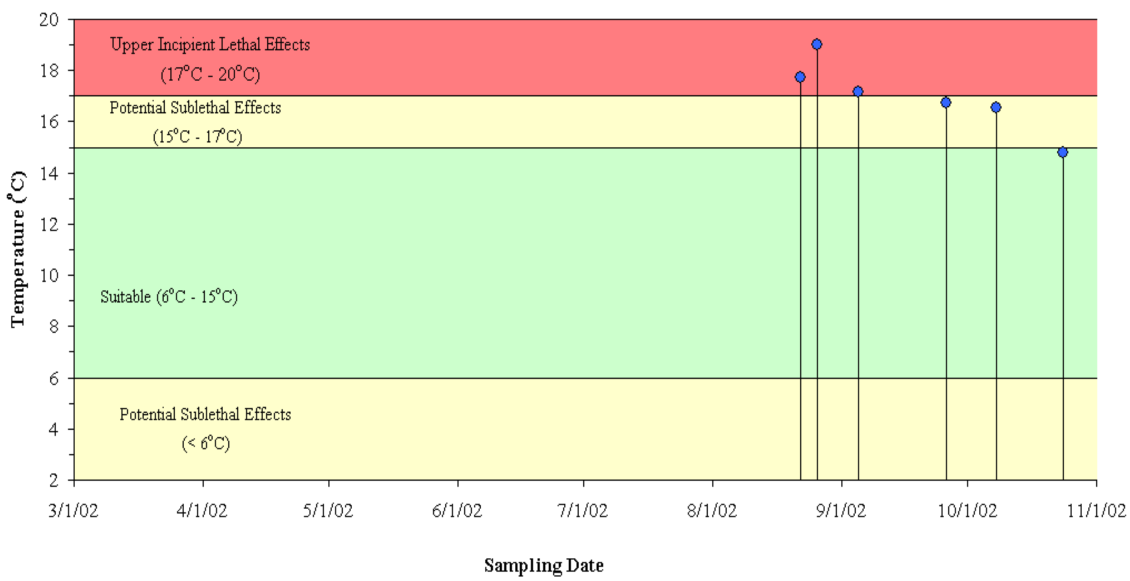
Feather River Near Mile Long Pond
N 39º 25' 40.4" W 121º 37' 34.0"
Pool 3-2



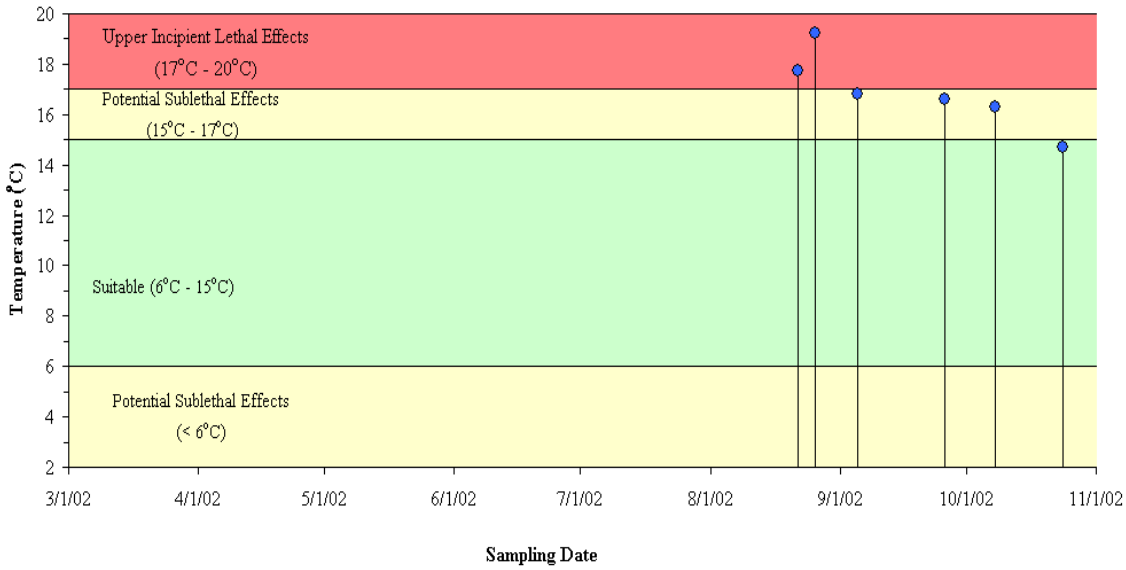
Feather River Downstream from Project Boundary
N 39º 23' 18.6" W 121º 37' 29.7"
Pool 3-3



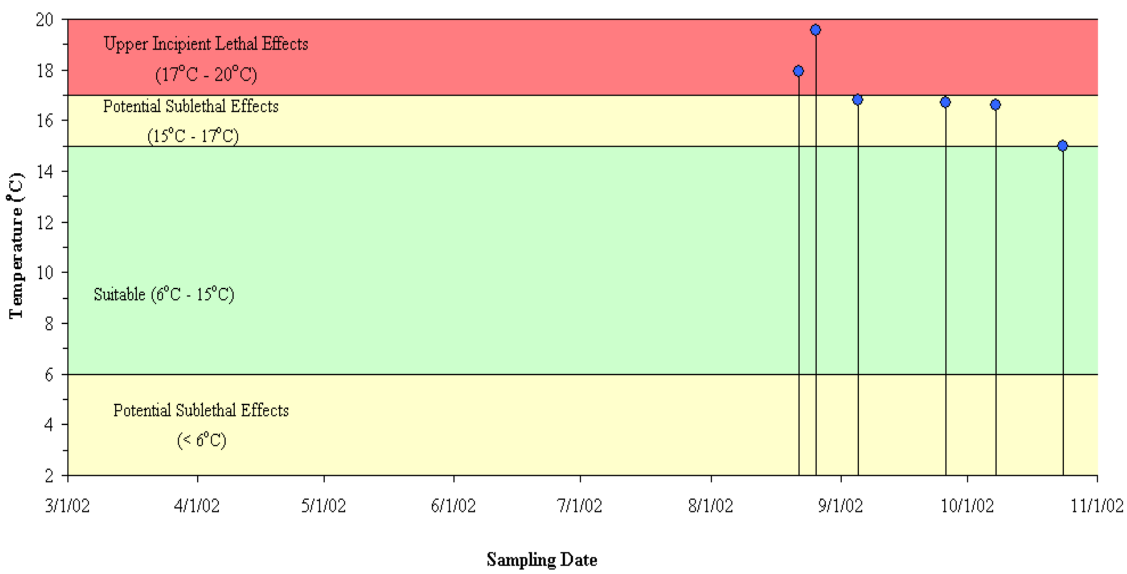
Feather River Near Gridley
N 39º 21' 59.6" W 121º 38' 50.3"
Pool 3-4



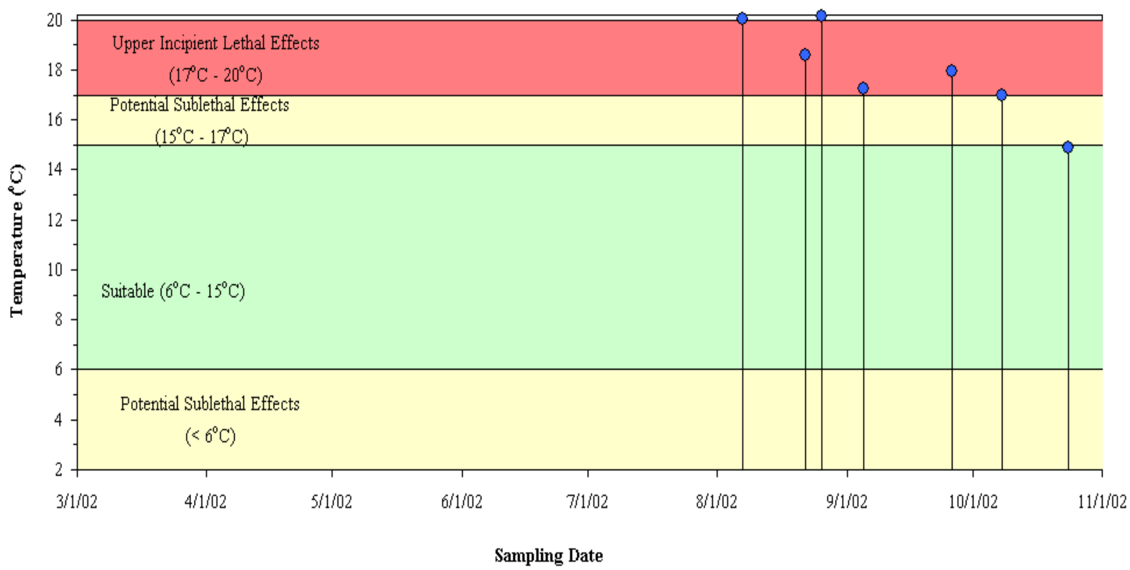
Feather River Upstream from Honcut Creek
N 39º 19' 39.5" W 121º 37' 32.9"
Pool 3-5



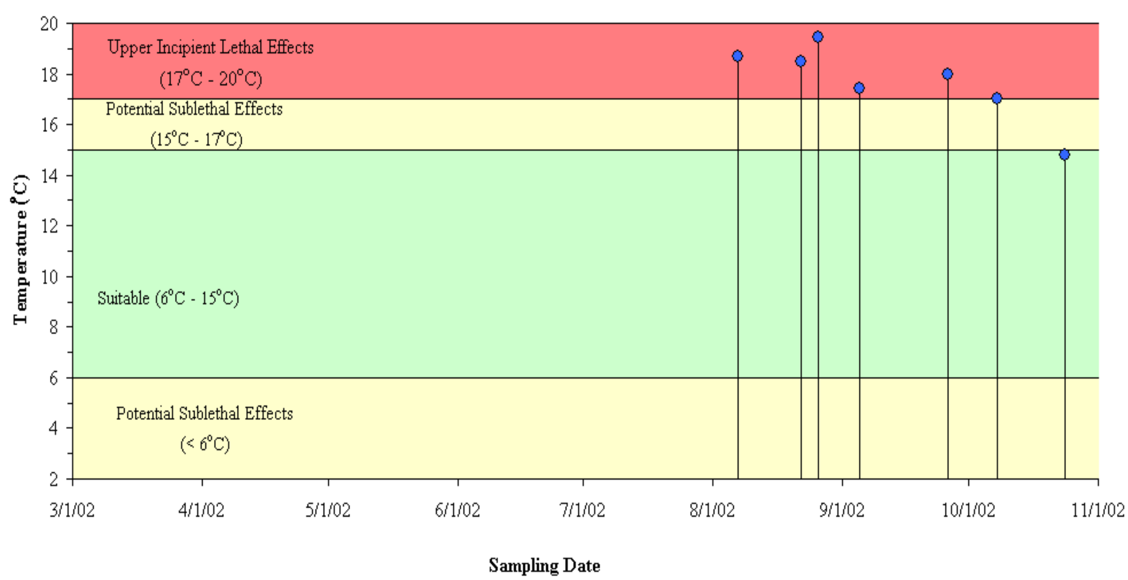
Feather River Near Live Oak
N 39º 16' 21.4" W 121º 37' 55.0"
Pool 4-1



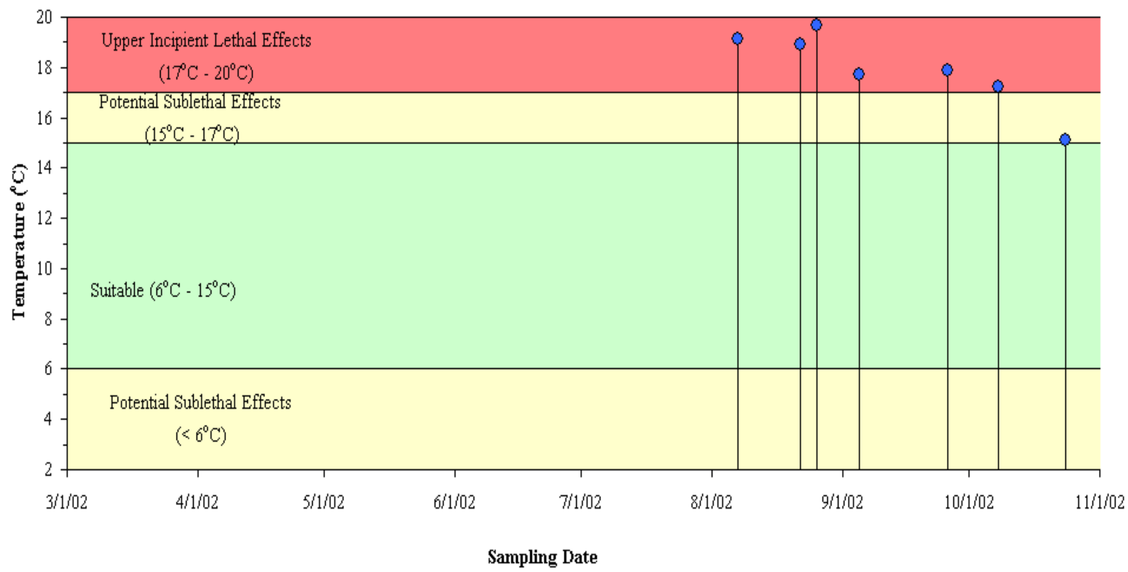
Feather River Upstream from Confluence with Yuba River
N 39º 7' 50.3" W 121º 35' 57.8"
Pool 4-2



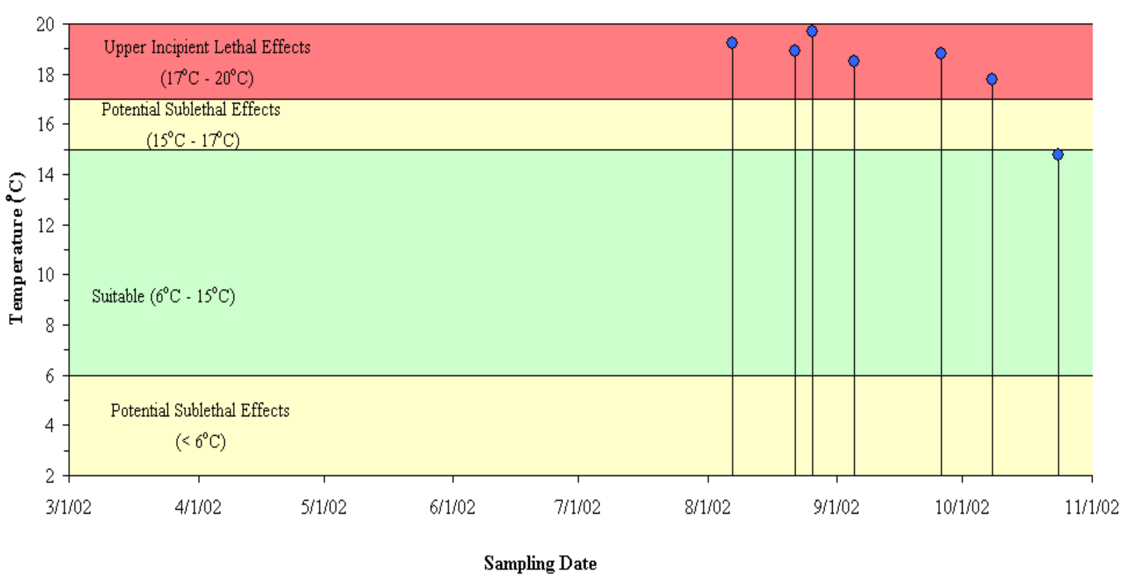
Feather River Near Shanghai Bend
N 39º 5' 22.4" W 121º 35' 59.1"
Pool 4-3



Feather River at Star Bend
N 39º 0' 42.0" W 121º 35' 57.3"
Pool 4-4



Feather River Near Verona
N 38º 47' 34.4" W 121º 37' 46.1"
Pool 4-5



State of California
The Resources Agency
Department of Water Resources

FINAL REPORT
EVALUATION OF OROVILLE FACILITIES OPERATIONS ON WATER TEMPERATURE-RELATED EFFECTS ON PRE-SPAWNING ADULT CHINOOK SALMON AND CHARACTERIZATION OF HOLDING HABITAT
SP-F10, TASKS 1D AND 1E

APPENDIX F
WATER TEMPERATURE INDEX VALUES AS TECHNICAL EVALUATION GUIDELINES

Oroville Facilities Relicensing
FERC Project No. 2100

JUNE 2004

WATER TEMPERATURE INDEX VALUES AS TECHNICAL EVALUATION GUIDELINES

INTRODUCTION

Water temperature is one of the most important environmental parameters affecting the distribution, growth, and survival of fish populations. Lethal water temperatures control fish populations by directly reducing population size, while sub-lethal water temperatures can control fish populations through effects on the physiology of fish life stages. Water temperatures may be particularly controlling of fish populations that are near their latitudinal distributional extremes as environmental conditions (e.g., water temperature) at distributional extremes may also be near the boundaries of conditions that allow the populations to persist. For example, California's Central Valley is at the southern limit of Chinook salmon distribution and studies have demonstrated that direct effects of high water temperatures are an important source of juvenile Chinook salmon mortality (Baker et al. 1995). Mortality associated with high water temperatures along with other sources of mortality have led to serious declines in Pacific salmonid populations to levels that require federal and state protection.

Myrick and Cech (2001) suggested that the primary cause for declines in Central Valley salmon and steelhead populations is the extensive construction of dams on rivers and streams used by salmonids for spawning and freshwater rearing. Dams have adversely affected fisheries resources by restricting Central Valley salmonids to less than 80 percent of their historical spawning habitat (Moyle 2002) and by altering the natural flow and water temperature regimes in the river sections available to spawning and rearing salmonids. Any additional water use or water diversion project will further affect flow and water temperatures potentially causing further adverse impacts to Central Valley salmonid populations. State and federal protection of salmonid resources requires impact assessment for all projects that could potentially affect species listed as threatened or endangered under state or federal endangered species acts. In order to assess the impacts of water diversion and water use projects in a consistent and effective manner, technical evaluation guidelines need to be developed. Specifically, salmonid life stages must be explicitly defined and life stage specific water temperature index values derived from comprehensive literature reviews must be clearly established. It is necessary to gain a broad understanding of how salmonids respond to water temperature regimes in order to successfully evaluate the effects of water temperature regimes on a given salmonid life stage or the entire life cycle. A literature review was conducted to: (1) clearly define each salmonid life stage, (2) provide logical and biologically sound rationale for each life stage definition and/or combination of life stages, (3) interpret the literature on water temperature effects to Chinook salmon and steelhead and their life stages, (4) consider effects of short-term and long-term exposure to constant or fluctuating temperatures, (5) establish biologically defensible water temperature index values to be used as guidelines for impact assessment.

METHODS

Water temperature index values were selected from a comprehensive literature review to reflect an evenly spaced water temperature range that provides conditions that are optimal to conditions that are lethal for each life stage of Chinook salmon and steelhead. Types of literature examined include: scientific journals, Master's theses and PhD dissertations, literature reviews, and agency publications (see Literature Reviewed). With respect to water temperature, the primary concern in the Central Valley relates to temperatures that may exceed upper salmonid tolerance limits rather than lower limits; therefore, index values were only established for water temperatures at and beyond the warmer tolerance zone. Water temperature index values were determined by placing emphasis on the results of laboratory experiments that examined how water temperature affects Central Valley Chinook salmon and steelhead as well as by considering regulatory documents, such as biological opinion reports from NOAA Fisheries. Studies on fish from outside the Central Valley were used to establish index values when local studies were unavailable. To avoid unwarranted specificity, only whole integers were selected as index values, thus support for index values was, in some cases, partially derived from literature supporting a water temperature that varied from the resultant index value by several tenths of a degree. For example, Combs and Burrows (1957) was considered to support an index value of 58°F despite the authors reporting that constant incubation temperatures between 42.5 and 57.5 resulted in normal development of Chinook salmon eggs. Rounding for the purposes of selecting index values is appropriate because the daily variation of experimental treatment temperatures is often high. For example, temperature treatments in Marine (1997) consisted of control (55.4 to 60.8°F), intermediate (62.6°F to 68.0°F), and extreme (69.8°F to 75.2°F) treatments that varied daily by whole degrees.

For Chinook salmon, water temperature index values were developed to separately evaluate the following life stages or where appropriate, combination of life stages: (1) adult immigration and holding, (2) adult spawning and embryo incubation, and (3) juvenile rearing and downstream movement. The juvenile rearing and downstream movement category includes fry rearing and downstream movement, fingerling rearing and downstream movement, and smolt emigration. For steelhead, water temperature index values were developed to separately evaluate the following life stages or where appropriate, combination of life stages: (1) adult immigration and holding, (2) adult spawning and embryo incubation, (3) fry and fingerling rearing and downstream movement, and (4) smolt emigration.

Inspection of the available literature on the effects of water temperature on salmonids revealed the need to interpret each document with caution and to verify the appropriateness of statements supported by references to other literature. Often source studies are cited incorrectly, and sometimes repeatedly. For example, Hinze (1959) examines the effects of water temperature on incubating Chinook salmon eggs, yet Hinze (1959) is cited *in* Boles et al. (1988), Marine (1992), and NOAA Fisheries (1997a) in statements regarding the effects of water temperature on holding Chinook salmon adults. Boles et al. (1988) and Marine (1992) were then incorrectly utilized by

McCullough (2001) in support of a section detailing how water temperature affects the viability of gametes developing in adults.

Most of the literature on salmonid water temperature requirements refers to “stressful”, “tolerable”, “preferred”, or “optimal” water temperatures or water temperature ranges. Spence et al. (1996) defined the **tolerable** water temperature range as the range at which fish can survive indefinitely. Thermal **stress** to fish is any water temperature change that alters the biological functions of the fish and which decreases probability of survival (McCullough 1999). **Optimal** water temperatures provide for feeding activity, normal physiological response, and behavior void of thermal stress symptoms (McCullough 1999). **Preferred** water temperature ranges are those that are most frequently selected by fish when allowed to freely choose locations along a thermal gradient (McCullough 1999). **Properly functioning condition** (PFC) is an additional term that will be used in the present document as defined by NOAA Fisheries *in* McElhany et al. (2000). McElhany et al. (2000) suggests that defining PFC is an ongoing process and the term will undergo further revision, but based on currently available knowledge is defined as the, “…freshwater spawning and rearing conditions necessary for the long-term survival of Pacific salmon populations.”

RESULTS

Chinook salmon

It has been suggested that separate water temperatures standards should be developed for each run-type of Chinook salmon. For example, McCullough (1999), states that spring-run Chinook salmon immigrate in spring and spawn in 3^{rd} to 5^{th} order streams and therefore face different migration and adult holding temperature regimes than do summer- or fall-run Chinook salmon, which spawn in streams of 5^{th} order or greater. However, to meet the objectives of the current literature review, run-types will not be separated because: (1) there is a depauperate amount of literature specific to each life stage of each run-type, (2) there is an insufficient amount of data available in the literature suggesting that Chinook salmon run-types respond to water temperatures differently, (3) the water temperature index values derived from all the literature pertaining to Chinook salmon that provide PFC for a particular life stage will be sufficiently protective of the life stage for each run-type, and (4) all run-types overlap in timing of adult immigration and in some cases are not easily distinguished (Healey 1991).

Adult Immigration and Holding

Description of Life Stage

After spending 3 to 4 years in the ocean Chinook salmon begin their return to freshwaters to spawn (Moyle 2002). Chinook salmon show considerable temporal variation in the timing of their spawning migrations and this life history variation is evident in the classification of Chinook salmon by run-type (i.e., fall-run, late fall-run, winter-run, and spring-run). In the Central Valley, the upstream migration of adult Chinook salmon occurs from October to April for the late fall-run, from December to July for the winter-run, from March to September for the spring-run, and from June to December for the fall-run (Fisher 1994). The holding period extends from the time that adult Chinook salmon enter their natal stream until the onset of spawning site selection. On the Feather River, the entire adult immigration and holding period lasts from March through October for spring-run Chinook salmon and from mid-July through December for fall-run Chinook salmon (DWR 2003a; Eaves 1982; Moyle 2002; NOAA Fisheries 1999; Sommer et al. 2001).

The adult immigration and adult holding life stages will be evaluated together, because it is difficult to determine the thermal regime that Chinook salmon have been exposed to in the river prior to spawning and in order to be sufficiently protective of pre-spawning fish, water temperatures that provide high adult survival and high egg viability must be available throughout the entire pre-spawning freshwater period. Although studies examining the effects of thermal stress on immigrating Chinook salmon are lacking, it has been demonstrated that thermal stress during the upstream spawning migration of sockeye salmon negatively affected the secretion of hormones controlling sexual maturation causing numerous reproductive impairment problems (Macdonald et al. in press as cited *in* McCullough et al. 2001).

Index Value Selection Rationale

One set of adult immigration and holding water temperature index values was established for all Chinook salmon run-types collectively to reflect an evenly spaced water temperature range that provides conditions that are optimal to conditions that are lethal for adult Chinook salmon during upstream spawning migrations and holding. The water temperature index values selected to evaluate the Chinook salmon and adult immigration life stage are 60, 64, and 68°F (Table 1). Although 56°F is referenced in the literature frequently as the upper water temperature limit required for upstream migration and holding, the references are not foundational studies and often are inappropriate citations. For example, many of the references to 56°F are based on Hinze (1959), which is a study examining the effects of water temperature on incubating Chinook salmon eggs. Boles et al. (1988), Marine (1992), and NOAA Fisheries (1997a) all cite Hinze (1959) in support of recommendations for a water temperature of 56°F for Chinook salmon immigration. Because 56°F is not strongly supported in the literature, it was not selected as an index value. The lowest water temperature index value selected was 60°F, because in the NOAA Fisheries biological opinion for the proposed operation of the Central Valley Project and State Water Project, 59°F to 60°F is reported as, “The upper limit of the optimal temperature range for adults holding while eggs are maturing” (NOAA Fisheries 2000). NOAA Fisheries (1997a) states, “Generally, the maximum temperature of adults holding, while eggs are maturing, is about 59°F to 60^{o}F" and that the, “Acceptable range for adults migrating upstream range from 57°F to 67^{o}F. ODEQ (1995) reports that, “…many of the diseases that commonly affect Chinook become highly infectious and virulent above 60^{o}F.” 64°F was chosen as an index value, because Berman (1990) suggests effects of thermal stress to pre-spawning adults are evident at water temperatures near 64°F and also because 64°F represents a mid-point value between the water temperature index values of 60°F and 68°F. Berman (1990) conducted a laboratory study to determine if pre-spawning water temperatures experienced by adult Chinook salmon influenced reproductive success, and found evidence suggesting latent embryonic abnormalities associated with water temperature exposure to pre-spawning adults occurs at 63.5°F to 66.2°F. 68°F was selected as an index value, because the literature suggests that thermal stress at water temperatures greater than or equal to 68°F is pronounced and severe adverse effects to immigrating and holding pre-spawning adults, including mortality can be expected (Berman 1990; Marine 1992; NOAA Fisheries 1997a). Because significant impacts to immigrating and holding adult Chinook salmon reportedly occur at water temperatures greater than or equal to 68°F, it was not necessary to select index values higher than 68°F.

Table 1. Chinook Salmon Adult Immigration and Holding Water Temperature Index Values and the Literature Supporting Each Value.

Index Value	Supporting Literature
60°F	Maximum water temperature for adults holding, while eggs are maturing, is approximately 59°F to 60°F (NOAA Fisheries 1997a); Acceptable water temperatures for adults migrating upstream range from 57°F to 67°F (NOAA Fisheries 1997a); Upper limit of the optimal water temperature range for adults holding while eggs are maturing is 59°F to 60°F (NOAA Fisheries 2000); Many of the diseases that commonly affect Chinook salmon become highly infectious and virulent above 60°F (ODEQ 1995); Mature females subjected to prolonged exposure to water temperatures above 60°F have poor survival rates and produce less viable eggs than females exposed to lower water temperatures (USFWS 1995)
64°F	Acceptable range for adults migrating upstream is from 57°F to 67°F (NOAA Fisheries 1997a); Disease risk becomes high at water temperatures above 64.4°F (EPA 2003); Latent embryonic mortalities and abnormalities associated with water temperature exposure to pre-spawning adults occur at 63.5°F to 66.2°F (Berman 1990)
68°F	Acceptable range for adults migrating upstream range from 57 to 67°F (NOAA Fisheries 1997a); For chronic exposures, an incipient upper lethal water temperature limit for pre-spawning adult salmon probably falls within the range of 62.6°F to 68.0°F (Marine 1992); Spring-run chinook salmon embryos from adults held at 63.5°F to 66.2°F had greater numbers of pre-hatch mortalities and developmental abnormalities than embryos from adults held at 57.2°F to 59.9°F (Berman 1990); Water temperatures of 68°F resulted in nearly 100 percent mortality of Chinook salmon during columnaris outbreaks (Ordal and Pacha 1963)

<u>Spawning and Embryo Incubation</u>

Description of Life Stage

In the Sacramento River basin, Chinook salmon spawning occurs from early January to April for the late fall-run, from late April to early August for the winter-run, from late August to October for the spring-run, and from late September to December for the fall-run (Fisher 1994). In the Feather River, adult spawning and embryo incubation occurs from September through mid-February (DWR 2004). The duration of embryo incubation is dependent on water temperature and can be variable (NOAA Fisheries 2002). In Butte and Big Chico creeks, emergence of spring-run Chinook salmon generally occurs from November through January (NOAA Fisheries 2002). In Mill and Deer creeks, colder water temperatures delay emergence to January through March (DFG 1998a). In the lower American River, fall-run Chinook salmon emergence generally begins in March (SWRI 2004).

The adult spawning and embryo (i.e. eggs and alevins) incubation life stage includes redd construction and egg deposition, and embryo incubation. Potential impacts to the adult spawning and embryo incubation life stages will be evaluated together using one set of water temperature index values because it is difficult to separate the effects of water temperature between life stages that are closely linked temporally-especially considering that studies elucidating how water temperature affects embryonic survival and development based on varying water temperature treatments on holding adults often report similar results to water temperature experiments conducted on fertilized eggs (Marine 1992; McCullough 1999; Seymour 1956).

Index Value Selection Rationale

Water temperature index values were selected from a comprehensive literature review to reflect an evenly spaced temperature range that provides conditions that are optimal to conditions that are lethal for Chinook salmon eggs during spawning site selection, spawning, and incubation (Table 2). Relative to the large body of literature pertaining to water temperature effects on Chinook salmon embryos, there are few laboratory experiments that specifically examine Chinook salmon embryo survival under different constant or fluctuating water temperature treatments, only one of which is recent (Combs et al. 1957; Hinze 1959; Johnson and Brice 1953; Seymour 1956; USFWS 1999). In large part, supporting evidence for index value selections was derived from the aforementioned laboratory studies and from regulatory documents (NOAA Fisheries 1993, 1997a, 2002). Field studies reporting river water temperatures during spawning were also considered (Dauble and Watson 1997; Groves and Chandler 1999). The water temperature index values selected to evaluate the Chinook salmon spawning and embryo incubation life stages are 56°F, 58°F, 60°F, and 62°F. Some literature suggests that water temperatures must be less than or equal to 56°F for maximum survival of Chinook salmon embryos (i.e. eggs and alevins) during spawning and incubation. NOAA Fisheries (1993) reported that optimum water temperatures for egg development are between 43°F and 56°F. USBR (2003) reports that water temperatures less than 56°F results in a natural rate of mortality for fertilized Chinook salmon eggs. USFWS (1995) reported a water temperature range of 41.0°F to 56.0°F for maximum survival of eggs and yolk-sac larvae in the Central Valley of California. 42.0°F to 56.0°F was suggested as the preferred water temperature for Chinook salmon egg incubation in the Sacramento River (NOAA Fisheries 1997a). Alevin mortality is reportedly significantly higher when Chinook salmon embryos are incubated at water temperatures above 56°F (USFWS 1999). NOAA Fisheries (2002) reported 56.0°F as the upper limit of suitable water temperatures for spring-run Chinook salmon spawning in the Sacramento River. High survival of Chinook salmon embryos has also been suggested to occur at incubation temperatures at or near 58.0°F.

Table 2. Chinook Salmon Spawning and Embryo Incubation Water Temperature Index Values and the Literature Supporting Each Value.

Index Value	Supporting Literature
56°F	Less than 56°F results in a natural rate of mortality for fertilized Chinook salmon eggs (USBR Unpublished Work); Optimum water temperatures for egg development are between 43°F and 56°F (NOAA Fisheries 1993); Upper value of the water temperature range (i.e., 41.0°F to 56.0°F) suggested for maximum survival of eggs and yolk-sac larvae in the Central Valley of California (USFWS 1995); Upper value of the range (i.e., 42.0°F to 56.0°F) given for the preferred water temperature for Chinook salmon egg incubation in the Sacramento River (NOAA Fisheries 1997a); Incubation temperatures above 56°F result in significantly higher alevin mortality (USFWS 1999); 56.0°F is the upper limit of suitable water temperatures for spring-run Chinook salmon spawning in the Sacramento River (NOAA Fisheries 2002); Water temperatures averaged 56.5°F during the week of fall-run Chinook salmon spawning initiation on the Snake River (Groves and Chandler 1999)
58°F	Upper value of the range given for preferred water temperatures (i.e., 53.0°F to 58.0°F) for eggs and fry (NOAA Fisheries 2002); Constant egg incubation temperatures between 42.5°F and 57.5°F resulted in normal development (Combs and Burrows 1957); The natural rate of mortality for alevins occurs at 58°F or less (USBR Unpublished Work)
60°F	100 percent mortality occurs during yolk-sac stage when embryos are incubated at 60°F (Seymour 1956); An October 1 to October 31 water temperature criterion of less than or equal to 60°F in the Sacramento River from Keswick Dam to Bend Bridge has been determined for protection of late incubating larvae and newly emerged fry (NOAA Fisheries 1993); Mean weekly water temperature at first observed Chinook salmon spawning in the Columbia River was 59.5°F (Dauble and Watson 1997); Consistently higher egg losses resulted at water temperatures above 60.0°F than at lower temperatures (Johnson and Brice 1953)
62°F	100 percent mortality of fertilized Chinook salmon eggs after 12 days at 62°F (USBR 2003b); Incubation temperatures of 62°F to 64°F appear to be the physiological limit for embryo development resulting in 80 to 100 percent mortality prior to emergence (USFWS 1999); 100 percent loss of eggs incubated at water temperatures above 62°F (Hinze 1959); 100 percent mortality occurs during yolk-sac stage when embryos are incubated at 62.5°F (Seymour 1956)

For example, USBR (2003) reported that the natural rate of mortality for alevins occurs at 58°F or less, Combs and Burrows (1957) concluded constant incubation temperatures between 42.5°F and 57.5°F resulted in normal development of Chinook salmon eggs, and NOAA Fisheries (2002) suggests 53.0 to 58.0°F is the preferred water temperature range for Chinook salmon eggs and fry. Johnson and Brice (1953) found consistently higher Chinook salmon egg losses resulted at water temperatures above 60.0°F than at lower temperatures. In order to protect late incubating Chinook salmon embryos and newly emerged fry, NOAA Fisheries (1993) has determined a water temperature criterion of less than or equal to 60.0°F be maintained in the Sacramento River from Keswick Dam to Bend Bridge from October 1 to October 31. However, Seymour (1956) provides evidence that 100 percent mortality occurs to late incubating Chinook salmon embryos when held at a constant water temperature greater than or equal to 60.0°F. The literature largely agrees that 100 percent mortality will result to Chinook salmon embryos incubated at water temperatures greater than or equal to 62.0°F (Hinze 1959; Seymour 1956; USBR Unpublished Work; USFWS 1999), therefore it was not necessary to select index values above 62°F. Similarly, mortality to spawning adult Chinook salmon prior to egg deposition (Berman 1990; Marine 1992) reportedly occurs at water temperatures above those at which embryo mortality results (i.e., 62°F) (Hinze 1959; Seymour 1956; USBR 2003b; USFWS 1999); therefore, an index value above 62°F was not required. Adult Chinook salmon pre-spawning mortality associated with exposure to high water temperatures is addressed in the adult immigration and holding life stage.

Juvenile Rearing and Downstream Movement

Description of Life Stage

The juvenile life stage is comprised of fry, fingerlings, and smolts; the parr stage is included in the fingerling category. Chinook salmon are fry from when the juvenile leaves the gravel of the spawning redd to swim up into the water column as a free-swimming fish until skeletal development is complete, at which point it reaches the fingerling stage (Bovee et al. 1998). Chinook salmon fry transition to the fingerling stage at approximately 45 to 60 mm (DWR 2003b; NOAA Fisheries 1997b; NOAA Fisheries 2003). Fingerling Chinook salmon become smolts when physiological changes occur that allow the juvenile to survive the transition from freshwater to saltwater during seaward migration. In addition to physiological changes, morphological changes also take place during smolting (Hoar 1988). Salmonid smolts can be distinguished from pre-smolts by their silvery appearance and relatively slim, streamlined body (Hoar 1988).

In the Sacramento River basin, the duration that juvenile Chinook salmon rear in natal streams varies according to run-type. Late fall-run juveniles emerge from the spawning substrate as fry from April to June and rear in their natal stream for 7 to 13 months (Fisher 1994). Winter-run juveniles emerge from the spawning substrate from July to October and rear for 5 to 10 months (Fisher 1994). Spring-run juveniles emerge from the spawning substrate from November to March and rear for 3 to 15 months (Fisher 1994). Fall-run juveniles emerge from the spawning substrate from December to March and rear for 1 to 7 months (Fisher 1994). Recent studies from the American and Feather Rivers indicate that most juvenile Chinook salmon move downstream as fry shortly after they emerge from the spawning gravel (DWR 2002; Snider and Titus 2000). In the Sacramento River, juvenile Chinook salmon move downstream during all months, as both fry and smolts (Moyle 2002). Water temperature is a major limiting factor for juvenile Chinook salmon, as it strongly affects survival and growth. Water temperatures that are too high can be lethal or cause sub-lethal effects such as reduced appetite and growth, increased incidence of disease, increased metabolic costs, and decreased ability for predator avoidance. The scientific literature indicates that a similar range of water temperatures provides positive growth and high survival for Chinook salmon fry, fingerlings, and smolts. Because Chinook salmon juveniles can be found in their natal stream rearing and moving downstream year-round as fry, fingerlings, or smolts and the scientific literature indicates that a similar range of water temperatures that are important for fry are also important for fingerlings and smolts, impacts to each phase of the juvenile life stage can be evaluated using a single set of water temperature index values.

Index Value Selection Rationale

Water temperature index values were selected from a comprehensive literature review to reflect an evenly spaced temperature range that provides conditions that are optimal to conditions that are lethal for juvenile rearing and downstream movement (Table 3). Index values were largely determined by placing emphasis on the results of laboratory experiments that examined how water temperature affects Central Valley Chinook salmon as well as by considering regulatory documents, such as biological opinion reports from NOAA Fisheries. Studies on fish from outside the Central Valley were used to supplement findings from local studies. The lowest index value selected was 60°F and was chosen, because regulatory documents as well as several source studies, including ones recently conducted on Central Valley Chinook salmon fry, fingerlings, and smolts, report 60°F as an optimal water temperature for growth (Banks et al. 1971; Brett et al. 1982; Marine 1997; NOAA Fisheries 1997a; NOAA Fisheries 2000; NOAA Fisheries 2001a; NOAA Fisheries 2002; Rich 1987a). Water temperatures below 60°F have also been reported as providing conditions optimal for fry and fingerling growth, but were not selected as index values, because the studies were conducted on fish from outside of the Central Valley (Brett 1952; Seymour 1956). Studies conducted using local fish may be particularly important because, *Oncorhynchus* species show considerable variation in morphology, behavior, and physiology along latitudinal gradients (Myrick 1998; Taylor 1990a; Taylor 1990b). More specifically, it has been suggested that salmonid populations in the Central Valley prefer higher water temperatures than those from more northern latitudes (Myrick and Cech Jr. 2000). Laboratory experiments suggest that water temperatures at or below 62.6°F provide conditions that allow for successful transformation to the smolt stage (Clarke and Shelbourn 1985; Marine 1997). 62.6°F was rounded and used to support an index value of 63°F. 65°F was selected as an index value, because it represents an intermediate value between 64.0°F and 66.2°F, at which both adverse and beneficial effects to juvenile salmonids have been reported to occur. For example, at temperatures approaching and beyond 65°F, sub-lethal effects associated with increased incidence of disease reportedly become severe for juvenile Chinook salmon (Johnson and Brice 1953; Ordal and Pacha 1963; Rich 1987a; EPA 2003). Conversely, numerous studies report that temperatures between 64.0°F and 66.2°F provide conditions ranging from suitable to optimal for juvenile Chinook salmon growth (Brett et al. 1982; USFWS 1995; Myrick and Cech 2001; EPA 2003; NOAA 2002; Cech and Myrick 1999). 68°F was selected as an index value because, at water temperatures above 68°F further sub-lethal effects become severe such as reductions in appetite and growth of juveniles as well as prohibiting successful smoltification (Marine 1997; Rich 1987a; Zedonis and Newcomb 1997). Chronic stress associated with water temperature can be expected when conditions reach the index value of 70°F. For example, growth becomes drastically reduced at temperatures close to 70.0°F and has been reported to be completely prohibited at 70.5°F (Brett 1982; Marine 1997). 75°F was chosen as the highest water temperature index value because high levels of direct mortality to juvenile Chinook salmon reportedly result at this water temperature (Rich 1987a). Other studies have suggested higher upper lethal water temperature levels Brett (1952) and Orsi (1971), but 75°F was chosen because it was derived from experiments using Central Valley Chinook salmon and it is a more rigorous index value representing a more protective upper lethal water temperature level. Furthermore, the lethal level determined in Rich (1987a) was derived using slow rates of water temperature change and thus, is ecologically relevant. Additional support for an index value of 75°F is provided from a study conducted by Baker et al (1995), in which a statistical model is presented that treats survival of Chinook salmon smolts fitted with coded wire tags in the Sacramento River as a logistic function of water temperature. Using data obtained from mark-recapture surveys, the statistical model suggests a 95% confidence interval for the upper incipient lethal water temperature for Chinook salmon smolts is 71.5°F to 75.4°F.

Table 3. Chinook Salmon Juvenile Rearing and Downstream Movement Water Temperature Index Values and the Literature Supporting Each Value.

Index Value	Supporting Literature
60°F	Optimum water temperature for Chinook salmon fry growth is between 55.0°F and 60°F (Seymour 1956); Water temperature range that produced optimum growth in juvenile Chinook salmon was between 54.0°F and 60.0°F (Rich 1987a); Water temperature criterion of less than or equal to 60.0°F for the protection of Sacramento River winter-run Chinook salmon from Keswick Dam to Bend Bridge (NOAA Fisheries 1993); Upper optimal water temperature limit of 60.8°F for Sacramento River fall-run Chinook salmon fry and fingerlings (Marine 1997); Upper water temperature limit of 60.0°F preferred for growth and development of spring-run Chinook salmon fry and fingerlings (NOAA Fisheries 2000, 2002); To protect salmon fry and juvenile Chinook salmon in the upper Sacramento River, daily average water temperatures should not exceed 60°F after September 30 (NOAA Fisheries 1997a); A water temperature of 60°F appeared closest to the optimum for growth of fingerlings (Banks et al. 1971); Optimum growth of Nechako River Chinook salmon juveniles would occur at 59°F at a feeding level that is 60 percent of that required to satiate them (Brett 1982)
63°F	Acceleration and inhibition of Sacramento River Chinook salmon smolt development reportedly may occur at water temperatures above 62.6°F (Marine 1997); Laboratory evidence suggest that survival and smoltification become compromised at water temperatures above 62.6°F (Zedonis and Newcomb 1997); Juvenile Chinook salmon growth was highest at 62.6°F (Clark and Shelbourn 1985)
65°F	Water temperatures between 45°F to 65°F are preferred for growth and development of fry and juvenile spring-run Chinook salmon in the Feather River (NOAA Fisheries 2002); Recommended summer maximum water temperature of 64.4°F for migration and non-core rearing (EPA 2003); Water temperatures greater than 64.0°F are considered not "properly functioning" by NOAA Fisheries in Amendment 14 to the Pacific Coast Salmon Plan (NOAA 1995); Fatal infection rates caused by *C. columnaris* are high at temperatures greater than or equal to 64.0°F (Fryer and Pilcher 1974 cited in EPA 2001); Disease mortalities diminish at water temperatures below 65.0°F (Ordal and Pacha 1963); Fingerling Chinook salmon reared in water greater than 65.0°F contracted *C. columnaris* and exhibited high mortality (Johnson and Brice 1953); Water temperatures greater than 64.9°F identified as being stressful in the Columbia River Ecosystem (Independent Scientific Group 1996 cited in EPA 2003); Juvenile Chinook salmon have an optimum temperature for growth that appears to occur at about 66.2°F (Brett et al. 1982); Juvenile Chinook salmon reached a growth maximum at 66.2°F (Cech and Myrick 1999); Optimal range for Chinook salmon survival and growth from 53.0°F to 64.0°F (USFWS 1995); Survival of Central Valley juvenile Chinook salmon declines at

Index Value	Supporting Literature
	temperatures greater than 64.4°F (Myrick and Cech Jr. 2001); Increased incidence of disease, reduced appetite, and reduced growth rates at 66.2 ± 1.4 (Rich 1987a)
68°F	Sacramento River juvenile Chinook salmon reared at water temperatures greater than or equal to 68.0°F suffer reductions in appetite and growth (Marine 1997); Significant inhibition of gill sodium ATPase activity and associated reductions of hyposmoregulatory capacity, and significant reductions in growth rates, may occur when chronic elevated temperatures exceed 68°F (Marine 1997); Water temperatures supporting smoltification of fall-run Chinook salmon range between 50°F to 68°F, the colder temperatures represent more optimal conditions (50°F to 62.6°F), and the warmer conditions (62.6°F to 68°F) represent marginal conditions (Zedonis and Newcomb 1997); Juvenile spring-run Chinook salmon were not found in areas having mean weekly water temperatures between 67.1°F and 71.6°F (Burck et al. 1980 as cited *in* McCullough 1999); Results from a study on wild spring-run Chinook salmon in the John Day River system indicate that juvenile fish were not found in areas having mean weekly water temperatures between 67.1°F and 72.9°F (Lindsay et al. 1986 as cited *in* McCullough 1999)
70°F	No growth at all would occur for Nechako River juvenile Chinook salmon at 70.5°F (Brett 1982); Juvenile spring-run Chinook salmon were not found in areas having mean weekly water temperatures between 67.1°F and 71.6°F (Burck et al. 1980); Results from a study on wild spring-run Chinook salmon in the John Day River system indicate that juvenile fish were not found in areas having mean weekly water temperatures between 67.1°F and 72.9°F (Lindsay et al. 1986); Increased incidence of disease, hyperactivity, reduced appetite, and reduced growth rates at 69.8 ± 1.8 (Rich 1987a)
75°F	For juvenile Chinook salmon in the lower American River fed maximum rations under laboratory conditions, 75.2°F was determined to be 100 percent lethal due to hyperactivity and disease (Rich 1987a); Lethal temperature threshold for fall-run juvenile Chinook salmon between 74.3 and 76.1°F (NAS 1972 as cited *in* McCullough 1999)

Steelhead

Adult Immigration and Holding

Description of Life Stage

Most Central Valley steelhead spend 1 to 2 years in the ocean before entering freshwater in August, with a peak in late September to October. Steelhead then hold in freshwater until rains increase flows allowing adults to enter lower reaches for spawning. Movements of adult steelhead from freshwater holding areas to spawning grounds can occur any time from December to March, with peak activities occurring in January and February (Moyle 2002). In the Feather River, the adult immigration and holding time period lasts from September through mid-April with peak migration extending from October through November (pers. comm., B. Cavallo 2004 ; McEwan 2001; Moyle 2002; S.P.Cramer & Associates 1995).

The adult immigration and adult holding life stages will be evaluated together, because it is difficult to determine the thermal regime that steelhead have been exposed to in the river prior to spawning and in order to be sufficiently protective of pre-spawning fish, water temperatures that provide high adult survival and high egg viability must be available throughout the entire pre-spawning freshwater period. Although studies examining the effects of thermal stress on immigrating steelhead are lacking, it has been demonstrated that thermal stress during the upstream spawning migration of sockeye salmon negatively affected the secretion of hormones controlling sexual maturation causing numerous reproductive impairment problems (Macdonald et al. in press as cited *in* McCullough et al. 2001).

Index Value Selection Rationale

Water temperatures can control the timing of adult spawning migrations and can affect the viability of eggs in holding females. Few studies have been published that examine the effects of water temperature on either steelhead immigration or holding and none have been recent (Billard and Breton 1977; Billard and Gillet 1981; and Strickland 1967 as cited *in* McCullough et al. 2001; Bruin and Waldsdorf 1975 as cited *in* Smith et al. 1983). The available studies suggest that adverse effects occur to immigrating and holding steelhead at water temperatures exceeding the mid 50°F range and that immigration will be delayed if water temperatures approach approximately 70°F (Table 4). Water temperature index values of 52°F, 56°F, and 70°F were chosen because: (1) they incorporate a range of values that provide PFC to conditions that are highly adverse, and (2) the available literature provided the strongest support for these values. Because of the paucity of literature pertaining to steelhead adult immigration and holding, an evenly spaced range of water temperature index values could not be achieved. 52°F was selected as a water temperature index value because it has been referred to as a "recommended" (USBR 2003), "preferred" (NOAA Fisheries 2002), and "optimum" (USBR 1997) water temperature for steelhead adult immigration. 56°F was selected as a water temperature index value because 56°F represents a water temperature above which adverse effects to migratory and holding steelhead begin to arise (Leitritz and Lewis 1980; McCullough et al. 2001; Smith et al. 1983). 70°F was selected as the highest water temperature index value because the literature suggests that water temperatures near and above 70.0°F present a thermal barrier to adult steelhead migrating upstream (McCullough et al. 2001; Strickland 1967 as cited in McCullough et al. 2001).

<u>Spawning and Embryo Incubation</u>

Description of Life Stage

Steelhead spawning includes the time period from redd construction until spawning is completed with the deposition and fertilization of eggs. The embryo incubation period extends from deposition until the juvenile emerges from the substrate as a free-swimming fry. In the Central Valley, steelhead spawning reportedly occurs from October through June (McEwan 2001) and embryo (i.e., eggs and alevins) incubation generally lasts 2 to 3 months after deposition (McEwan 2001; Moyle 2002; Myrick and Cech Jr. 2001). In the Feather River, steelhead spawning and embryo incubation extends from December through May, with peak spawning occurring in January and February (Busby et al. 1996; pers. comm., B. Cavallo 2004 ; California Bay Delta Authority Website ; Moyle 2002). Like Chinook salmon, the steelhead embryo life stage is the most vulnerable life stage to water temperature. Because the initial embryo incubation water temperatures are a function of spawning water temperatures, one set of water temperature index values was established to evaluate spawning adults and incubating embryos.

Table 4. Steelhead Adult Immigration and Holding Water Temperature Index Values and the Literature Supporting Each Value.

Index Value	Supporting Literature
52°F	Preferred range for adult steelhead immigration of 46.0°F to 52.0°F (NOAA Fisheries 2000; NOAA Fisheries 2002; State Water Resources Control Board 2003); Optimum range for adult steelhead immigration of 46.0°F to 52.1°F (USBR 1997); Recommended adult steelhead immigration temperature range of 46.0°F to 52.0°F (USBR 2003)
56°F	To produce rainbow trout eggs of good quality, brood fish must be held at water temperatures not exceeding 56.0°F (Leitritz and Lewis 1980); Rainbow trout brood fish must be held at water temperatures not exceeding 56°F for a period of 2 to 6 months before spawning to produce eggs of good quality (Bruin and Waldsdorf 1975 *in* Smith et al. 1983); Holding migratory fish at constant water temperatures above 55.4°F to 60.1°F may impede spawning success (McCullough et al. 2001)
70°F	Migration barriers have frequently been reported for pacific salmonids when water temperatures reach 69.8°F to 71.6°F (McCullough et al. 2001); Snake River adult steelhead immigration was blocked when water temperatures reached 69.8 (Strickland 1967 as cited *in* McCullough et al. 2001); A water temperature of 68°F was found to drop egg fertility in vivo to 5 percent after 4.5 days (Billard and Breton 1977 as cited in McCullough et al. 2001)

Index Value Selection Rationale

Few studies have been published regarding the effects of water temperature on steelhead spawning and embryo incubation (Redding and Schreck 1979; Rombough 1988). Because anadromous steelhead and non-anadromous rainbow trout are genetically and physiologically similar, studies on non-anadromous rainbow trout were also considered in the development of water temperature index values for steelhead spawning and embryo incubation (McEwan 2001; Moyle 2002). From the available literature, water temperatures in the low 50°F range appear to support high embryo survival with substantial mortality to steelhead eggs reportedly occurring at water temperatures in the high 50°F range and above (Table 5). Water temperature index values of 52°F, 54°F, 57°F, and 60°F were selected for two reasons. First, the available literature provided the strongest support for water temperature index values at or near 52°F, 54°F, 57°F, and 60°F. Second, the index values reflect an evenly distributed range representing optimal to lethal conditions for steelhead spawning and embryo incubation. Although some literature suggests water temperatures ≤ 50°F are optimal for steelhead spawning and embryo survival (Myrick and Cech Jr. 2001; Timoshina 1972), a larger body of literature suggests optimal conditions occur at water temperatures ≤ 52°F (Humpesch 1985; NOAA Fisheries 2000; NOAA Fisheries 2001a; NOAA Fisheries 2002; State Water Resources Control Board 2003; USBR 1997; USFWS 1995). Therefore, 52°F was selected as the lowest water temperature index value. 54°F was selected as the next index value, because although most of the studies conducted at or near 54.0°F report high survival and normal development (Kamler and Kato 1983; Redding and Schreck 1979; Rombough 1988), some evidence suggests that symptoms of thermal stress arise at or near 54.0°F (Timoshina 1972;

Humpesch 1985). Thus, water temperatures near 54°F may represent an inflection point between properly functioning water temperature conditions and conditions that cause negative effects to steelhead spawning and embryo incubation. 57°F was selected as an index value because embryonic mortality increases sharply and development becomes retarded at incubation temperatures greater than or equal to 57.0°F. Velsen (1987) provided a compilation of data on rainbow trout and steelhead embryo mortality to 50 percent hatch under incubation temperatures ranging from 33.8°F to 60.8°F that demonstrated a 2-fold increase in mortality for embryos incubated at 57.2°F compared to embryos incubated at 53.6°F. In a laboratory study using gametes from Big Qualicum River, Vancouver Island, steelhead mortality increased to 15 percent at a constant temperature of 59.0°F compared to less than 4 percent mortality at constant temperatures of 42.8°F, 48.2°F, and 53.6°F (Rombough 1988). Also, alevins hatching at 59.0°F were considerably smaller and appeared less well developed than those incubated at the lower temperature treatments. From fertilization to 50 percent hatch, Big Qualicum River steelhead had 93 percent mortality at 60.8°F, 7.7 percent mortality at 57.2°F, and 1 percent mortality at 47.3°F and 39.2°F (Velsen 1987).

Table 5. Steelhead Spawning and Embryo Incubation Water Temperature Index Values and the Literature Supporting Each Value.

Index Value	Supporting Literature
52°F	Rainbow trout from Mattighofen (Austria) had highest egg survival at 52.0°F compared to 45.0°F, 59.4°F, and 66.0°F (Humpesch 1985); Water temperatures from 48.0°F to 52.0°F are suitable for steelhead incubation and emergence in the American River and Clear Creek (NOAA Fisheries 2000, 2001, 2002); Optimum water temperature range of 46.0°F to 52.0°F for steelhead spawning in the Central Valley (USFWS 1995); Optimum water temperature range of 46.0°F to 52.1°F for steelhead spawning and 48.0°F to 52.1°F for steelhead egg incubation (USBR 1997); Upper limit of preferred water temperature of 52.0°F for steelhead spawning and egg incubation (State Water Resources Control Board 2003).
54°F	Big Qualicum River steelhead eggs had 96.6 percent survival to hatch at 53.6°F (Rombough 1988); Highest survival from fertilization to hatch for *Salmo gairdneri* incubated at 53.6°F (Kamler and Kato 1983); Emergent fry were larger when North Santiam River (Oregon) winter steelhead eggs were incubated at 53.6°F than at 60.8°F (Redding and Schreck 1979); The upper optimal water temperature regime based on constant or acclimation water temperatures necessary to achieve full protection of steelhead is 51.8°F to 53.6°F (EPA 2001); From fertilization to hatch, rainbow trout eggs and larvae had 47.3 percent mortality (Timoshina 1972); Survival of rainbow trout eggs declined at water temperatures between 52.0 and 59.4°F (Humpesch 1985); The optimal constant incubation water temperature for steelhead occurs below 53.6°F (McCullough et al. 2001)
57°F	From fertilization to 50 percent hatch, Big Qualicum River steelhead had 93 percent mortality at 60.8°F, 7.7 percent mortality at 57.2°F, and 1 percent mortality at 47.3°F and 39.2°F (Velsen 1987); A sharp decrease in survival was observed for rainbow trout embryos incubated above 57.2°F (Kato 1980 as cited *in* Kamler and Kato (1983)
60°F	From fertilization to 50 percent hatch, Big Qualicum River steelhead had 93 percent mortality at 60.8°F, 7.7 percent mortality at 57.2°F, and 1 percent mortality at 47.3°F and 39.2°F (Velsen 1987); From fertilization to 50 percent hatch, rainbow trout eggs from Ontario Provincial Normendale Hatchery had 56 percent survival when incubated at 59.0°F (Kwain 1975);

Fry and Fingerling Rearing and Downstream Movement

Description of Life Stage

The juvenile life stage is comprised of fry, fingerlings, and smolts. Steelhead are fry from when the juvenile leaves the gravel of the spawning redd to swim up into the water column as a free swimming fish until skeletal development is complete, at which point it reaches the fingerling stage (Bovee et al. 1998). Steelhead fry transition to the fingerling stage at approximately 45 to 60 mm (Bovee et al. 1998; DWR 2003b; Moyle 2002; NOAA Fisheries 1997b). After Central Valley steelhead emerge from the gravel, juveniles remain in freshwater for 1 to 3 years before smolting and migrating to saltwater (Myrick and Cech 2001). Shapovalov and Taft (1954) suggest that most Waddell Creek, California steelhead rear in freshwater for two years.

Index Value Selection Rationale

Like other salmonids, growth, survival, and successful smoltification of juvenile steelhead are controlled largely by water temperature. The duration of freshwater residence for juvenile steelhead is long relative to that of Chinook salmon, making steelhead more vulnerable to changes of the natural water temperature regime. Central Valley juvenile steelhead have high growth rates at water temperatures in the mid 60°F range, but require lower water temperatures to successfully undergo the transformation to the smolt stage (Tables 6 and 7). Water temperature index values of 65°F, 68°F, 72°F, and 75°F were selected to represent an evenly distributed range of water temperatures that provide optimal to lethal conditions for steelhead fry and fingerling rearing and downstream movement. 65°F was selected as the lowest water temperature index value, because NOAA Fisheries (2002) reported 65°F as the upper limit preferred for growth and development of Sacramento and American River juvenile steelhead. Also, 65°F was found to be within the preferred water temperature range (i.e., 62.6°F to 68.0°F) and supported high growth of Nimbus strain juvenile steelhead (Cech Jr. and Myrick 1999). Cherry et al. (1977) and Kaya et al. (1977) as cited in McCullough (1999) both observed an upper preference water temperature near 68.0°F for juvenile rainbow trout, duplicating the upper preferred limit for juvenile steelhead observed in Cech and Myrick (1999). Because of the strength of evidence supporting 68.0°F as the upper preferred limit for juvenile *Oncorhynchus mykiss*, 68°F was selected as a water temperature index value. 72°F was selected as a water temperature index value, because symptoms of thermal stress in juvenile steelhead have been reported to arise at water temperatures approaching 72°F. For example, physiological stress to juvenile steelhead in Northern California streams was demonstrated by increased gill flare rates, decreased foraging activity, and increased agonistic activity as stream temperatures rose above 71.6°F (Nielsen et al. 1994). Also, 72°F was selected as a water temperature index value because 71.6°F has been reported as an upper avoidance water temperature (Kaya et al. 1977 *in* McCullough 1999) and an upper thermal tolerance water temperature (Ebersole et al. 2001 *in* EPA 2002) for juvenile rainbow trout. 75°F was selected as the highest water temperature index value because, NOAA Fisheries and EPA report that direct mortality to rearing juvenile steelhead results when stream temperatures reach 75.0°F (EPA 2002; NOAA Fisheries 2001b).

Table 6. Steelhead Fry and Fingerling Rearing and Downstream Movement Water Temperature Index Values and the Literature Supporting Each Value.

Index Value	Supporting Literature
65°F	Upper limit of 65°F preferred for growth and development of Sacramento River and American River juvenile steelhead (NOAA Fisheries 2002); Nimbus juvenile steelhead growth showed an increasing trend with water temperature to 66.2°F, irrespective of ration level or rearing temperature (Cech and Myrick 1999); The final preferred water temperature for rainbow fingerlings was between 66.2 and 68°F (Cherry et al. 1977); Nimbus juvenile steelhead preferred water temperatures between 62.6°F and 68.0°F (Cech and Myrick 1999); Rainbow trout fingerlings preferred or selected water temperatures in the 62.6°F to 68.0°F range (McCauley and Pond 1971)
68°F	Nimbus juvenile steelhead preferred water temperatures between 62.6°F and 68.0°F (Cech and Myrick 1999); The final preferred water temperature for rainbow trout fingerlings was between 66.2°F and 68°F (Cherry et al. 1977); The upper avoidance water temperature for juvenile rainbow trout was measured at 68°F to 71.6°F (Kaya et al. 1977 *in* McCullough 1999))
72°F	Increased physiological stress, increased agonistic activity, and a decrease in forage activity in juvenile steelhead occur after ambient stream temperatures exceed 71.6°F (Nielsen et al. 1994); The upper avoidance water temperature for juvenile rainbow trout was measured at 68°F to 71.6°F (Kaya et al. 1977 *in* McCullough 1999)); Estimates of upper thermal tolerance or avoidance limits for juvenile rainbow trout (at maximum ration) ranged from 71.6°F to 79.9°F (Ebersole et al. 2001 *in* EPA 2002)
75°F	The maximum weekly average water temperature for survival of juvenile and adult rainbow trout is 75.2°F (EPA 2002); Rearing steelhead juveniles have an upper lethal limit of 75.0°F (NOAA Fisheries 2001b); Estimates of upper thermal tolerance or avoidance limits for juvenile rainbow trout (at maximum ration) ranged from 71.6 to 79.9°F (Ebersole et al. 2001 *in* EPA 2002)

Smolt Emigration

Description of Life Stage

Fingerling steelhead become smolts when physiological changes occur that allow the juvenile to survive the transition from freshwater to saltwater during seaward migration. In addition to physiological changes, morphological changes also take place during smolting (Hoar 1988). Salmonid smolts can be distinguished from pre-smolts by their silvery appearance and relatively slim, streamlined body (Hoar 1988). Steelhead smolts migrate out to sea at 1 to 3 years of age, at 10 to 25 cm FL (Moyle 2002). In the Feather River, steelhead smolt emigration occurs from January through June (pers. comm., B. Cavallo 2004 ; McEwan 2001; Newcomb and Coon 2001; Snider and Titus 2000; USFWS 1995).

Index Value Selection Rationale

Laboratory data suggest that smoltification, and therefore successful emigration of juvenile steelhead is directly controlled by water temperature (Adams et al. 1973; Adams et al. 1975). Water temperature index values of 52°F and 55°F were selected to evaluate the steelhead smolt emigration life stage, because most literature on the effects of water temperature to steelhead smolting suggest that water temperatures less than 52°F (Adams et al. 1975; Myrick and Cech Jr. 2001; Rich 1987b) or less than 55°F (EPA 2003; McCullough et al. 2001; Wedemeyer et al. 1980; Zaugg and Wagner 1973) are required for successful smoltification to occur. Adams et al. (1973) tested the effect of water temperature (43.7°F, 50.0°F, 59.0°F or 68.0°F) on the increase of gill microsomal Na^{+}-, K^{+}-stimulated ATPase activity associated with parr-smolt transformation in steelhead and found a twofold increase in Na^{+}-, K^{+}-ATPase at 43.7 and 50.0°C, but no increase at 59.0°F or 68.0°F. In a subsequent study, the highest water temperature where a parr-smolt transformation occurred was at 52.3°F (Adams et al. 1975). The results of Adams et al. (1975) were reviewed in Myrick and Cech (2001) and Rich (1987b), which both recommended that water temperatures below 52.3°F are required to successfully complete the parr-smolt transformation. Zaugg and Wagner (1973) examined the influence of water temperature on gill ATPase activity related to parr-smolt transformation and migration in steelhead and found ATPase activity was decreased and migration reduced when juveniles were exposed to water temperatures of 55.4°F or greater. In a technical document prepared by EPA to provide temperature water quality standards for the protection of Northwest native salmon and trout, water temperatures less than or equal to 54.5°F were recommended for emigrating juvenile steelhead (EPA 2003).

Table 7. Steelhead Smolt Emigration Water Temperature Index Values and the Literature Supporting Each Value.

Index Value	Supporting Literature
52°F	Steelhead successfully smolt at water temperatures in the 43.7°F to 52.3°F range (Myrick and Cech 2001); Steelhead undergo the smolt transformation when reared in water temperatures below 52.3°F, but not at higher water temperatures (Adams et al. 1975); Optimum water temperature range for successful smoltification in young steelhead is 44.0°F to 52.3°F (Rich 1987b)
55°F	ATPase activity was decreased and migration reduced for steelhead at water temperatures greater than or equal to 55.4°F (Zaugg and Wagner 1973); Water temperatures should be below 55.4°F at least 60 days prior to release of hatchery steelhead to prevent premature smolting and desmoltification (Wedemeyer et al. 1980); In winter steelhead, a temperature of 54.1°F is nearly the upper limit for smolting (McCullough et al. 2001); Water temperatures less than or equal to 54.5°F are suitable for emigrating juvenile steelhead (EPA 2003)